Engineering Library

In This Issue: Hoisting the Suspended Span of the Quebec Bridge

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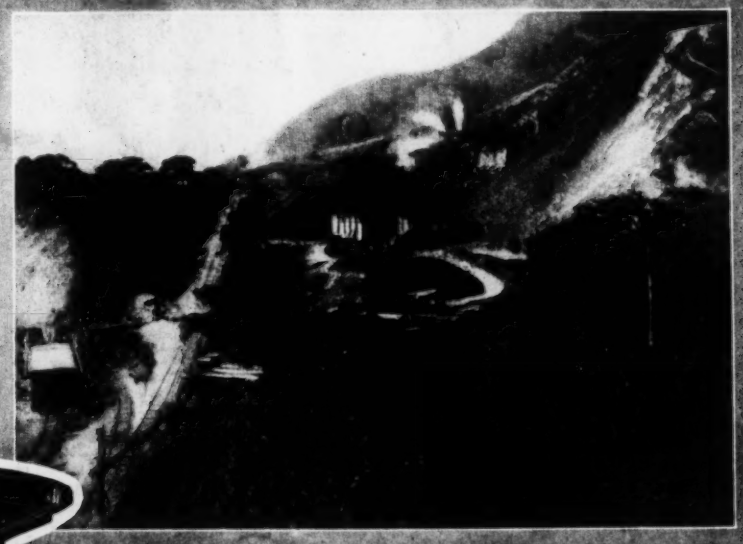
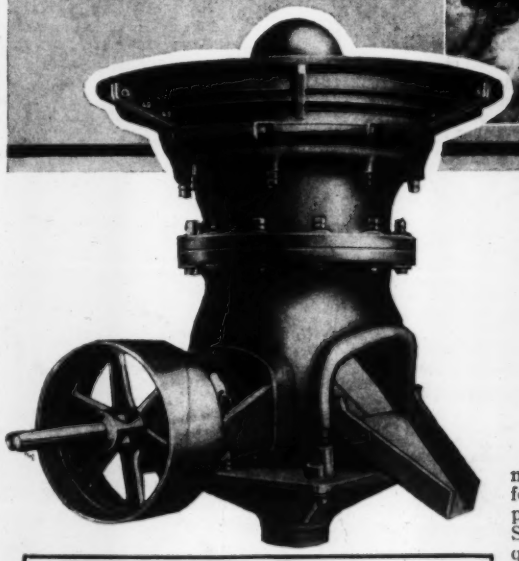
80% of the Rock Crushing on the Panama Canal





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The photographs show how about 200 tons of 14 x ¾-in. Lackawanna Arch-Web Sheet Piling has been driven in 16 and 25-foot lengths to protect bad spots on the face of the earthen levee on the Ohio River, where there was a tendency to slough off.

The upper picture shows the method of holding back the piling wall at the top by means of rods fastened to a row of concrete anchor blocks along the railroad track.

The sheet piling was driven by the D. F. McCarthy Co. of Cairo under direction of the Lakes and Rivers Commission of the State of Illinois and is a consistent addition to other protective walls of Lackawanna Steel Sheet Piling driven nearby about two years ago. Also as this repeat order came two years after the first installation had been tested, it would seem that Lackawanna Steel Sheet Piling must be perfectly satisfactory to the State Engineers.

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Engineering News

VOLUME 76 AUGUST 31, 1916 NUMBER 9

Straightening 70-Ft. I-Beams Bent by Flood

The complete reconstruction of the Susquehanna River bridge of the Cumberland Valley R.R., at Harrisburg, Penn., is being carried on from a working trestle built on the rock floor of the river and extending alongside the bridge. The trestle consists of timber bents set on sills on the river bottom, the rock preventing the driving of piles. The striking feature of the structure is the use of

In order to build another trestle it was necessary either to buy more beams or straighten the ones recovered. Economy urged the latter course, and the blacksmith of the Robert Grace Contracting Co. was called upon to perform this difficult task.

The views and sketch show the method used to straighten the beams. Two gin-poles were erected and

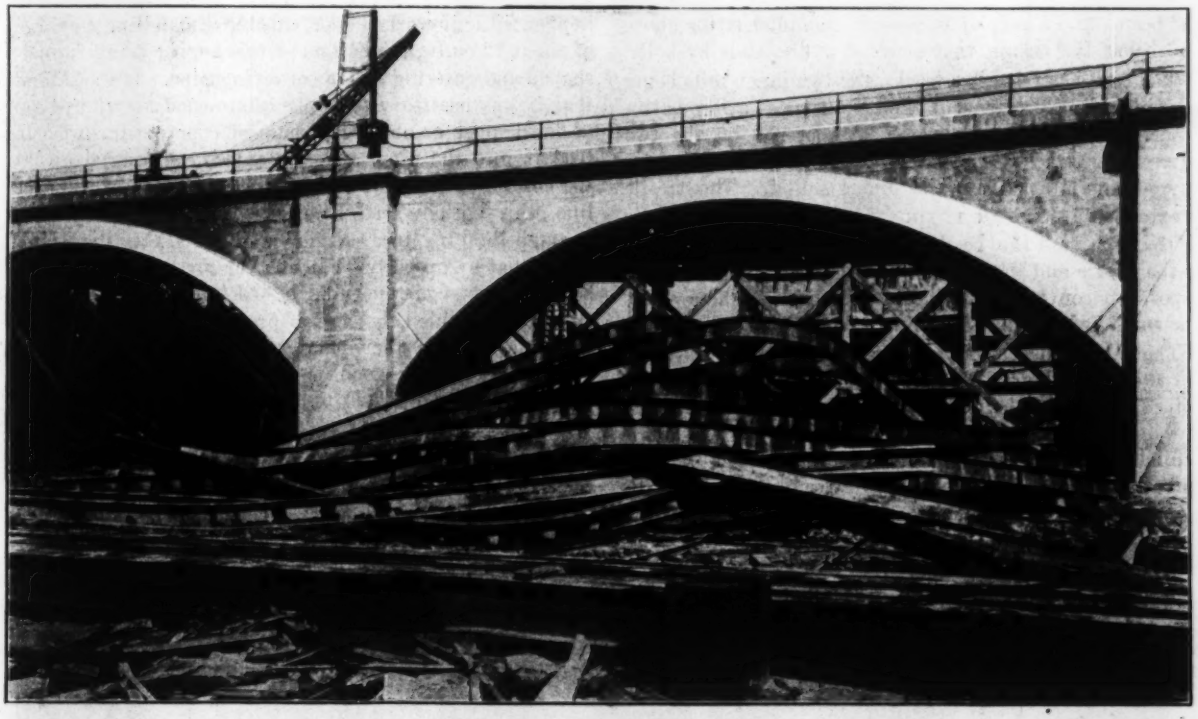


FIG. 1. TRESTLE STRINGERS BENT BY FLOOD, AWAITING STRAIGHTENING BY FIRE, HARRISBURG BRIDGE, CUMBERLAND VALLEY R.R.

70-ft. 15-in. I-beams for stringers. These are not drilled and would have brought a good price at the end of the season. However, an unexpected and disastrous flood in June washed out the trestle and wrapped the I-beams around the concrete pier noses. Fig. 1 gives some idea of the deformation.

It was imperative that a new trestle be erected just as soon as the water went down sufficiently. In the meantime recovery of the beams went forward. A Browning crane, with 60-ft. boom, running on top of the bridge picked up the beams from the river and transported them to an island that is crossed by the Susquehanna bridge. As there was but one track, this fishing had to be done between trains, so as not to interrupt traffic.

guyed, and one of the deformed beams was suspended between the poles, with the convex side toward the ground. Under the curved portion a fire was built of waste from the wood forms.

As the bend heated, the two ends of the beam began to lower. The beam was then guyed to deadmen so that it would straighten true to its original line. It dropped down on rails placed to receive it. The work was accomplished in a very satisfactory manner. Some of the straightened beams are shown in the foreground of Fig. 1. These beams are now employed in the new trestle built since the flood. They are entirely satisfactory for this service, although minor kinks remained and they could hardly have been used in a structural frame.

The trestle consists of six-post bents on four plumb posts and two batter posts, 23 ft. apart on centers; 12x12-in. caps; 2x6 sash timbers and bracings; four stringers, 15-in. I-beams under each rail. The 70-ft. I-beams alternated with 24-ft. lengths, the long ones in each case facing an arch span, while the short length is at the pier. The

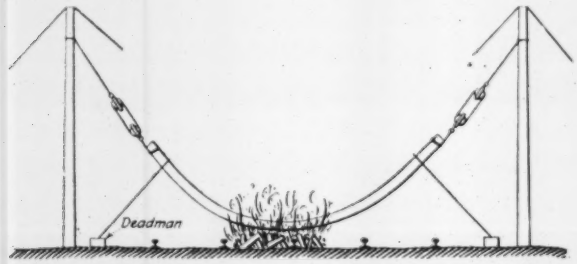


FIG. 4. SETUP FOR STRAIGHTENING A 70-FT. I-BEAM

lengths lapped each other without connection, no rivets or bolts being used. Rail spikes held the beams down on the caps. Midway between them the beams were braced by bridging consisting of plank diaphragms cut in between the beams and a pair of transverse clamping strips above and below the beams, tied together at the ends by bolts.

The trestle carried two tracks, the two inner rails being of standard gage to permit the operation of a locomotive crane. The dinkeys and concrete cars run on the two narrow-gage tracks. There is a double turnout from these narrow-gage tracks into the mixer siding. The trestle is extended around the mixing plant and material trestle so that the cars can be drawn out on the main portion of the trestle and then backed around the mixing plant to a position convenient to the island spans. These spans are concreted by the Browning crane noted.

The new bridge at Harrisburg, as described in *Engineering News*, Mar. 23, 1916, p. 537, is a two-track reinforced concrete viaduct, made up of 45 arch spans averaging 76 ft. each. It is being built in two longitudinal halves, the first having been completed in 1915 and the second now approaching completion. F. P. Kemon is superintendent for the contractor, while Crosby Tappan supervises the work for the Cumberland Valley R.R., under the direction of T. H. Kennedy.

Pneumatic Concreting and Its Development

By J. H. Graham*

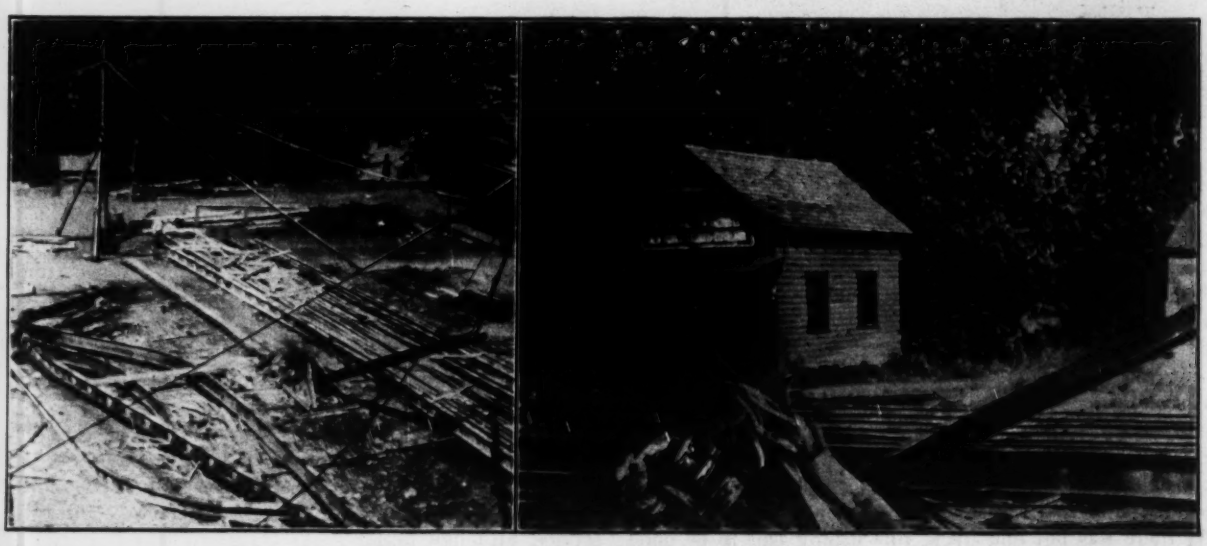
Some eight or nine years ago, several engineers separately conceived the idea of conveying concrete through pipe by means of compressed air or steam. The first attempts were to convey concrete made up of comparatively small stone (1 in.) through 4-in. pipe. The greatest difficulty encountered was the constant clogging of the pipe, owing to arching, or toggle-like packing of the concrete. The natural inclination was to enlarge the pipe and not to hunt for the cause of the clogging. Experiments were made first with 4-in. pipe, then 6-in. and finally 8-in. pipe, with only imperfect success.

When the writer first came in touch with the pneumatic process, some five years ago, the tendency was to increase the size of pipe to 10 in., to relieve the clogging. The writer took issue with this theory at once, on account of the cost and difficulty of moving large-size pipe, and the waste of power or compressed air.

The first pneumatic conveyors consisted of a cast-iron hopper with air-worked door, capable of handling a charge of about 12 cu.ft., the bottom of this hopper being funnel-shaped and entering into a conveying pipe. It was found that it was necessary to apply compressed air at the top of the hopper or above the mass of concrete in order to feed it into the pipe, and also inject compressed air at the bottom of the pipe, acting in the direction of the pipe line, this bottom feed being the means of propulsion through the pipe line. At Tallulah Falls, Ga., the writer found that by properly balancing the pressures at top and bottom inlets, concrete could be fed into the pipe without clogging, but this balancing of pressure depended entirely upon the skill of the operator. Properly operated, the machine gave very good results, conveying concrete at Tallulah Falls (in 1912) to a maximum distance of some 1,100 ft.

Experience showed that cast-iron hoppers are unsafe, as on occasions they would explode from high pressure, and later a sheet-metal hopper was designed, quick-acting valves being placed on the air inlets.

*President, Pneumatic Placing Co., 2 Rector St., New York.



FIGS. 2 AND 3. TWO VIEWS OF BEAM-STRAIGHTENING PROCESS

Various facts were learned during the early work: The relative size of stone had no effect upon clogging; small stone would clog as quickly and as easily as large stone. Gravel would clog easier than crushed stone, and small gravel easier than large gravel (this in 8-in. pipe). If a clog occurred and was found to be absolutely air-tight, it would be impossible to remove it by any amount of pressure applied. On the other hand, with even the very smallest opening through the mass of concrete for a whisper of air to pass, tapping of the pipe when pressure was applied would remove the clog.

Where hopper-type conveyors have been employed they have also been used as mixers, there being a mixing action while the materials were blown through the pipe. The mixture has generally passed the requirements of engineers throughout the country.

During 1913 and 1914 successful work attracted a great deal of attention to the pneumatic mixer, notably on foundations for the Ontario Power Co. at Niagara Falls; on the O. K. Creek sewer tunnel in Kansas City, Mo.; a tunnel under the Interborough power house at 74th St., New York City; an abutment wall at Akron, Ohio; foundations for the Otis Steel Co. at Cleveland, Ohio, etc. These were for one-bag batches, except that on the Ontario Power Co. work the first two-bag batch or 20-cu.ft. mixer was tried, and after a few slight changes in the hopper was successful.

During 1915 the pneumatic process proved itself as especially adapted for lining tunnels—the Kennerdell tunnel; the Mill Creek sewer tunnel, St. Louis; Mile Rock tunnel, San Francisco; aqueduct tunnels, Los Angeles;

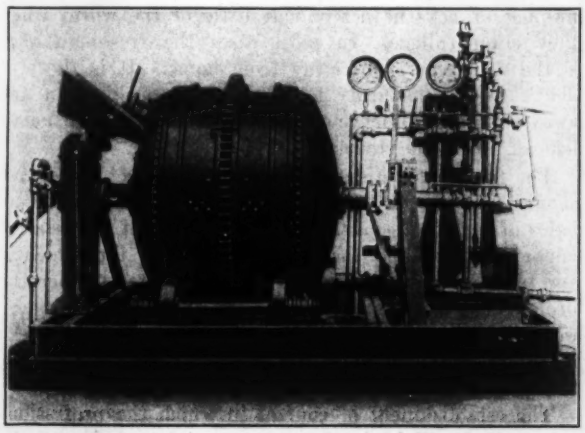


FIG. 1. ROTARY CONCRETE MIXER ATTACHED TO PNEUMATIC DISCHARGE

Sandy Ridge tunnel. As much as $2 per cu.yd. was saved; the labor cost in many instances was not more than 10c. per cu.yd.

On outside work the conveyors did not prove so successful, because of the large amount of compressed air necessary and the difficulty of moving the 8-in. pipe.

On the theory that the process should be made of universal application on all kinds of concrete work, the writer placed it on every type of work on which the engineer or contractor would allow it to be placed. More valuable data and experience were gained from the failures than from the successes. Several years of both success and failure left the following deductions: (1) Smaller pipe is necessary in order to give flexibility of distribution. (2) The amount of compressed air wasted in the operation should be conserved, as the compressed air used was not doing its maximum amount of work. (3) The possibility of clogging should be eliminated, and the process should be made fool-proof. (4) Extreme care in the manipulation should not be necessary; the operation ought to be put upon the plane of ordinary labor. (5) The flow of the concrete through the pipe should be uniform and under uniform pressure, eliminating the

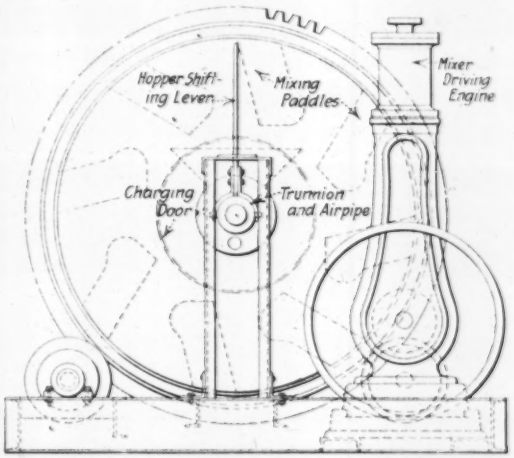


FIG. 2. SECTION THROUGH MIXER

kick or jar in the pipe line due to the uneven distribution of pressures within the batch of concrete as it passes through the pipe.

Two years ago it was found possible to convey concrete through pipe the diameter of which equaled twice the diameter of the stone; in other words, 1½-in. stone would require 3-in. pipe, 2-in. stone 4-in. pipe. This decrease in the size of the pipe from 8 in. decreases the amount of air necessary. Further, by a mechanical arrangement developed recently, the flow of the concrete in the conveying pipe can be controlled. These two developments have resulted in the design of a radically new machine.

Mixer with Air Discharge for Universal Service

The machine is a unit which combines the action of mechanical mixer and pneumatic conveyor. The outlet pipe is made to suit the quantity of concrete desired per hour or per day, the size of stone used being only a minor factor. The construction is such that the flow of the concrete into the pipe is uniform.

It has been found that the time required for conveying a given amount of concrete is practically the same for small pipe as for large pipe. Thus, by varying the flow the velocity of outflow can be regulated to suit location and purpose.

One form of the machine is shown by the photograph. The air inlet here is at the right, discharge at the left, through the trunnion. The charging door is at the left, outside the trunnion box. In the interior are two circles of mixing blades and a small middle hopper, with controllable connection to the discharge. Air can be admitted both below and above the hopper.

Changed design, indicated in the sketch, includes combining air inlet and discharge at the same end of the machine, and using a central charging door in the other end. This door, operated by air, makes it possible to charge while the machine is running.

How Can Professional Misfits in Engineering Be Avoided?

By W. M. Wilson*

In discussing the efficiency of engineering schools, it is well to remember that a university is about the only factory that attempts to produce a high grade finished product without adequate control of its raw material. If metal is to be used for a counterweight, it needs only one requirement, weight; but if it is to be used for a bridge it must meet each of a dozen or more requirements as to chemical composition, heat treatment, strength, ductility, etc. In the manufacturing world, the more refined the product the more searching is the selection of the raw material. Yet the specifications for the raw material from which engineers are to be made contain but one requirement; that they shall be graduates of an accredited high school. A boy having qualified in this one respect, our universities agree to make him into an engineer with absolutely no regard for his fitness for or his interest in engineering work.

Different products require different qualities in the raw material from which they are made. A high grade of steel is satisfactory for watch springs, but it is worthless for a chemist's crucible. Both require the very best material of its kind, but they require different kinds of material. Likewise for the so-called learned professions, the requirements are not only high, but they are also specific. A man who would make a good minister might be a poor engineer, or a man who could succeed as a lawyer might fail as a doctor, not because the qualifications are necessarily higher in the one case than in the other, but because the qualifications are different.

Scientists have taught the manufacturer to use steel where steel is needed, copper where copper will best serve, etc., but no one has yet shown how to select good lawyer material for making lawyers, or doctor material for producing doctors. In general, a youth in America is allowed the greatest freedom in selecting his profession, and this must continue to be the case. It is not, however, necessary that he should continue to select his profession without knowledge of the qualifications for success in the profession selected or the nature of the work involved.

The expression, "continue to select his profession without knowledge," has been used advisedly, for it must be admitted that there is but little knowledge of the qualifications required for or of the relative opportunities for success in the different professions. Everybody knows that the Mississippi Valley is more fertile than the New England hills, and that the economic conditions for the poor are better in America than in Europe; but who knows the relative average income of the lawyer, doctor, farmer, editor, merchant, manufacturer, etc.?

Among the American people, knowledge of the relative agricultural resources of the different states is quite universal; but of the knowledge much more important to them—the relative opportunities in the various trades and professions—the great masses of American people are totally ignorant.

In this age of specialized university courses in which college training is provided for all lines of commercial as well as professional activities, enrollment in a college course usually means the selection of a life's activities. Statistics show that 85% of the graduates of the College of Engineering of the University of Illinois are following some line of engineering work. This means that for the most part, college graduates soon, if not immediately, upon graduating from the high school select the line of work which they are to follow through life. The decision at this age is often governed by a mere whim or fancy, and is seldom based upon a knowledge of the opportunities offered or of special qualifications to meet the requirements of the work to be followed. Under these conditions it is no reflection upon the universities that their engineering schools graduate many a man who is not an engineer, never will be and never should be an engineer. He has not the qualifications of an engineer, he does not like the environment in which engineering work is done, and he loathes the work itself. These are facts which vitally affect a man's entire life, yet, under our present system, he does not learn them in many cases until after he has been out of college a number of years. Thus are wasted many of the best years of life, a tragedy for which some one is responsible and which should be prevented.

In order to end this evil the writer proposes that students in our universities and colleges shall not be permitted to decide upon the course they are to take until they have completed one year of college work; and that a considerable portion of the freshman year should be devoted to a thorough study of the characteristics of the professions.

This will delay an important decision a year at the age when a boy is developing very rapidly. A large number of boys have seen but little of the world when they enter college. In most cases the freshman year is the first year spent away from home. It is the student's first opportunity to meet others of his own age away from the influence of his parents and the provincialism of his home town.

The fact that the student is about to select his course should give him an interest in a study of the characteristics of the professions. He should learn of the relative opportunities which the professions offer; their mental and physical requirements; the environments in which the professional work is conducted; the amount and kind of work which they require, etc. With this knowledge fresh in the student's mind at the time he selects his course, the number of misfits should be materially reduced.

The establishment of courses in which the professions are studied will lead to a more exact knowledge of the relative merits of the professions. The facts being at hand they will be eagerly sought by the interested public.

The fact that courses are not selected until the beginning of the second year in college should present no great administrative difficulties. It is true that all freshmen would have to take substantially the same work, but it should be possible to select at least one year's work which will be beneficial alike to men of all professions.

The selection of a college course, after a study of the relative opportunities offered and the qualities required by the different professions and trades, would come as a real decision, not something drifted into, and would therefore command some thought. Furthermore the decision would come at a time when the student possesses facts governing the decision. An intelligent selection

*Assistant Professor of Structural Engineering, University of Illinois.

of the line of work to be followed should result in a much smaller number of misfits than exist under the present system.

The present system makes the student narrow. His course being selected before he has much knowledge of any profession, his mind is wrapped up in the one thing that he is studying to the exclusion of all others. His college course is made up of subjects closely related to his special field. Upon graduation he will join a professional society devoted to his specialty, and he will associate with men in the same line of work. The further he goes the deeper is his rut, and it is only by an almost superhuman effort that he is able to check this tendency to become narrow. The result is, if he is an engineer, he dies knowing nothing but a single line of engineering; or, if a doctor, he will know of nothing but medicine. If he has selected the line of work for which he is preeminently fitted, he is fortunate; if not, he is so hedged in with ignorance and prejudice that he can see nothing of the opportunities in other fields.

There is a work in the world for every man and every man should search diligently for his particular job.

Scouting for Water Power

By D. N. Showalter*

Most water powers are developed by capitalists who have their attention called to the project by a promoter, who usually gets a good fee for his work. Most electric companies operating in a certain territory like to keep well informed concerning all possible water power in that territory, both with an eye to future expansion and with a desire to control all strategic situations, thus keeping competitors out. Then also there are the large chemical, electrochemical and pulp companies, which must have cheap power. These companies search for large water powers, remote from ordinary markets. Such powers can usually be had and developed cheaply. Lastly, there is the engineer who has become a promoter, or the business man who has made a successful power-project promotion by some happy chance and is looking for another similar project. All these scout for water power.

The way in which the problem is approached is, first, by getting a fair idea of the areas where the general elevation of the country changes and where there is a fair or good rainfall; and, secondly, to study thoroughly all available Government topography sheets of the region.

In rough country, where are found the headwaters of streams, there are two types of water power—(1) the small stream with a high head, and (2) the large stream with a steep slope, flowing through a valley or gorge before it reaches the lowlands. There is also usually a large amount of power in the lower courses of rivers, but it is so expensive to develop that it generally is not attractive unless there is an excellent market near.

Of the foregoing powers the one with the high head and small flow is usually most attractive, for it can be developed with a low dam and small pipe line, and it can usually be made to yield nearly all primary power by moderate storage. This storage, being small, does not overflow much land, and the land is usually inexpensive. Then, too, with the headwaters of a stream regulated, the other water-power sites farther down become more valuable and can be developed later. The disadvantage of power developed on the headwaters of a stream is that it is usually far from a market; but this is not a great drawback, since long-distance transmission is not too expensive.

When the scout has found from the map a good prospective power on the headwaters of a stream, he takes a reliable contour sheet (most recent Government topography sheets are sufficiently accurate) and with one leg of a compass at the storage-dam site he draws a series of circles. The lowest contour within reasonable distance of the storage dam is a possible power-house site. It is not necessarily on the same river, but caution has to be used in diverting water from one watershed to another, particularly if the water is diverted from one county to another or from one state to another. Theoretically, mill owners downstream must prove damage, which of course they cannot easily do, if floods are lessened and minimum river stages are increased. In reality, mill owners imagine damages, and public opinion is nearly always against a water-power corporation.

Having found the best power-house site, the topography is investigated for "backbone" ridges out which to lead the pipe line, so that it will be under low pressure as far as possible. It is aimed then to plunge down a uniform slope, as steep as possible (up to say 45°) to the power house.

Having thus located a possible water power on paper, the scout journeys to the proposed site. It has been a safe rule to talk "timber" when looking for water power and vice versa. Nowadays one can even be looking for a place to take moving pictures, when hard pressed for an excuse for being in a sparsely settled country. After having arrived at the village nearest the site and inquired the ownership of timber lands in that vicinity, the scout travels in the neighborhood a little while, acquiring all the information he can as to land values, titles and pending lawsuits regarding titles. He generally then repairs to the office of the register of deeds at the county seat and there gets from the deed books sufficient information to plot out a rough map of the property owners in the storage basin. In some states the value of the properties at the last sale is also recorded in the deed. In the adjoining office of the clerk of the courts he finds records of all suits in progress concerning title to land in the county. In some Southern states land titles are so poor and there are so many conflicting grants that no capitalist will risk large amounts of money until the title is proved to be absolutely clear. Capitalists do not like to buy lawsuits.

Now the scout investigates the available market. The large-scale post-office maps of the Government are excellent for this purpose. The power house is plotted on one of these maps, and circles are struck with it as a center. These circles are variously of 25-mi., 50-mi. radius, and so on. The power consumed in the different towns in the zones is found by visiting them or from the directories of the various industries, as, for instance, the "Textile Directory," which gives exhaustive information concerning cotton mills. After having made several gagings of the stream, the scout is ready to make his preliminary report.

In cases when this report has been favorably accepted and capital raised to promote the project, the next step has been to purchase the land. Possibly the scout was lucky, and all the flowage is on one or two big timber tracts. Timbermen may usually be dealt with easily, they reserving the timber and mineral rights and deeding the

*Frick's Lock, Penn.

water rights. When such a deed is drawn, there is sometimes put in a joker clause, in which the owner of mineral rights is allowed to use all the water necessary for mining. In a high-head development, where water is scarce, this could be so interpreted as absolutely to ruin the power company. The kind of mining should be specified, as should also the maximum amount of water to be diverted.

If there are a number of small farms or lots in the storage basin, the scout at once tries to find an intelligent resident of the vicinity, whom he hires at a small monthly salary as a land agent. A local man can nearly always buy land cheaper and quicker than an outsider. Before this move is made, however, the scout makes absolutely sure that there are no mills with waterwheels of any kind, nor any water or power rights on his stream. If any are discovered, they are bought up first, before there is any talk concerning the new project. It is usually cheaper and easier to buy whole farms than only flowage rights. A local attorney, of course, examines titles and draws up papers for all sales.

To forestall gossip, the scout sometimes has stationery printed for a large orchard company and actually sets out some "cull" trees, or he has formed a hunting-preserve company and starts to stock the land with game. The whole idea has been to prevent people from knowing that one certain area is required.

It generally pays when most of the land has been purchased, to have the selected flood contour run, to make sure that no land has been omitted. Especial care is then taken to locate the contour in tributary stream valleys and with two or three feet in height allowed all around for waves and seepage. If all the land is not bought when the contour is run, two or three false lines are run also, to mislead the residents. All stakes are well concealed. In fact, on a preliminary survey of this kind stakes are often not used. All fences, streams, houses, etc., near the contour are located and mapped. In a high-head development it usually has paid to make the reservoir large enough to equalize the stream over several years instead of only one. The slight extra expense of the reservoir dam is small compared with the dependable annual primary power output.

It is sometimes thought best to option property before buying, but the writer has found that most small farmers do not understand options and are afraid of them. On the other hand, money is usually scarce and a payment of several hundred dollars in cash is quite attractive. It has been found well to make the balance of the payments on the properties in three to six annual installments. This has not only given the proposition a chance to get on its feet and earning before final payments are made, but also it sometimes has happened that a property is not needed or title is poor, in which case the bargain may be thrown out if only a small first payment has been made.

Finally, after the rights-of-way for the pipe line and the "fee simple" lands for the power house have been bought, a complete and accurate boundary and contour survey is made and plotted. The outside boundaries of the whole tract bought are well marked with stone monuments. Such a map is now ready to be turned over to the engineers for final design and construction.

The water-power scout always bears in mind that the value of water power on the lower reaches of a stream depends on the variation of flow of the stream, on the available market and on the price of coal. There usually has been little or no profit in secondary power alone; it is only in connection with a fair amount of primary power that it is valuable.

To determine the most probable minimum flow of a stream is usually a long and complicated process. In most cases the absolute primary output is based on at least a 50-yr. period. Commonly the stream-flow records of recent years are supplemented by rainfall records running back from 20 to 50 yr., so that the probable minimum flow has been safely predicted.

There are hundreds of thousands of horsepower on available streams still going to waste in both the eastern and western parts of the United States, but with the decreasing cost of electric power produced in large steam units, it is only the most attractive of these powers that can now be financed.

Train-Shed with Columns Between the Tracks

In train-sheds having a series of spans supported by intermediate columns the almost universal plan in this country has been to place the columns in the center of the platforms. The columns are sometimes serious obstructions when the platforms are crowded.

The train-shed of the new Lehigh Valley R.R. passenger terminal at Buffalo, N. Y., is notable in having its supporting columns placed between the tracks, thus leaving the platforms unobstructed. This arrangement

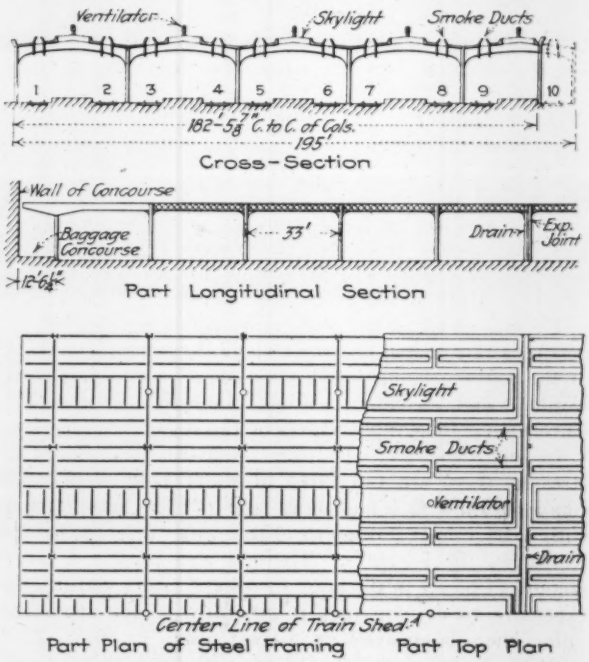


FIG. 1. SECTION AND ELEVATION OF TRAIN-SHED AT BUFFALO, N. Y.
Note that the supporting columns are between the tracks

permits an effective skylight plant, and it also gives a roof of greater height, since its lower portions come over the tracks, where 16-ft. clearance is required. One obvious objection to this location of the columns is the possibility of damage by a derailed train, but in a terminal station derailment is improbable.

This train-shed is of the low-roof type patented by Lincoln Bush, consulting engineer, New York, and was designed by him. E. B. Ashby is Chief Engineer of the Lehigh Valley R.R.

The general design of the train-shed is shown in Fig. 1. It consists of five spans, or bays, covering ten tracks and five platforms. At present, however, the tenth track will be omitted, and the north bay will be narrower than the others. The reason for this is that the track and outer columns would be directly over the old Hamburg sewer, costly reconstruction of which would be necessary. In fact, additional expense is incurred by a cantilever construction necessary to carry the present columns clear of the sewer.

The columns are spaced transversely 38 ft. 10⅜ in. c. to c., the platforms being 14 ft. wide and the tracks spaced alternately 24 ft. 2⅜ in. and 14 ft. 8 in. c. to c. They are connected by the roof girders, forming transverse bents. The clear headway is 16 ft. from the rails to the lower sides of the smoke ducts and about 18 ft. of the train-shed have six angles. The girders have ⅜-in. webs, with two flange angles and three cover plates on each chord. Where the girders pass through the smoke ducts, they are cased with concrete and fitted with cast-iron deflectors on the under side to protect them from the cinders and blast of the engines.

Cantilever girders support the present columns along the north side, as foundation pedestals could not be provided without interference with the sewer. The arrangement is shown in Fig. 2. The girders are pairs of 20-in. I-beams, having the inner ends embedded in anchor blocks of concrete (forming pedestals for the next row of columns). Near the outer end each girder rests on a base plate and grillage on a concrete block. The distance between supports is 21 ft. 9⅜ in., and the cantilever projection is 5 ft. 3 in. to center of column. A line of 20-in. I-beams along the ends of the cantilevers serves to support the curtain wall.

The concrete roof slab is 3 in. thick, with curb walls to carry the skylights, which are continuous between the

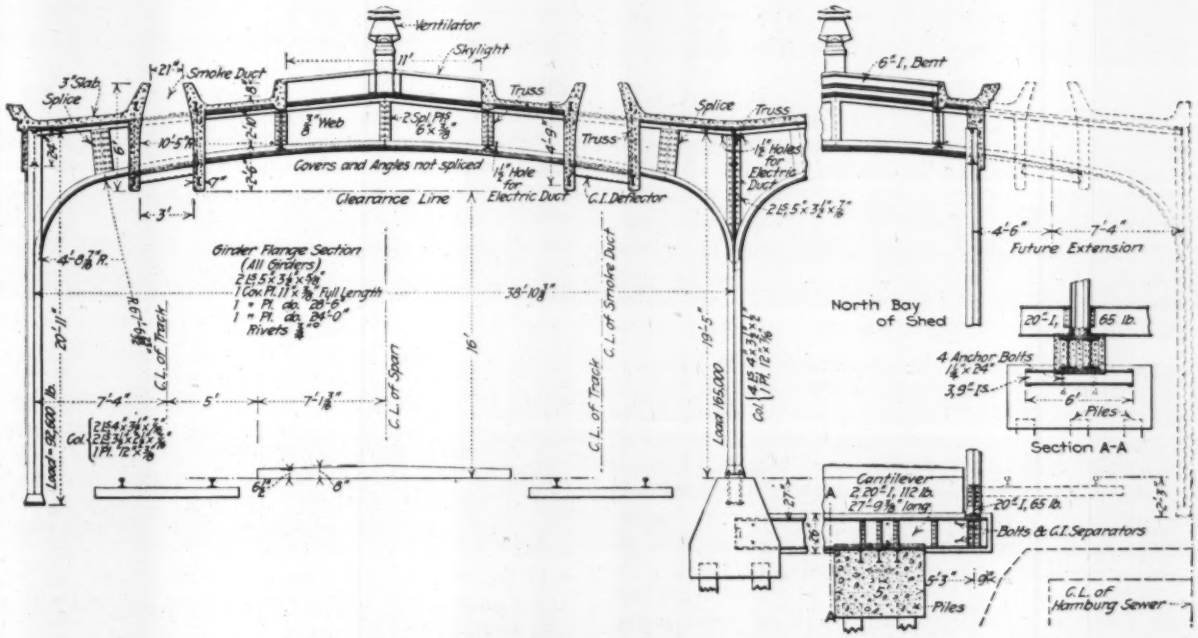


FIG. 2. DETAILS OF TRAIN-SHED; LEHIGH VALLEY R.R.

The cantilever support for the temporary north wall and columns is to avoid interference with a large sewer

at the center of the platform. Longitudinally the columns are spaced 33 ft. c. to c. There are 26 bents, making a length of 825 ft., the total length being increased to 842½ ft. by a short cantilever projection at each end.

The bents are connected by lines of lattice girders; these are placed over the columns, in the smoke-duct walls and at the sides of the skylights. Expansion bearings are provided at each fifth bent. The track and roof have a descending grade of 0.32% from the headhouse end. Roof drains are provided at the expansion bents, with downspouts on the columns and leading to the sewer.

The columns are of H-section, composed of a web plate and four angles, the web plate (and greater dimension) being parallel with the track in order to get minimum width. The outside columns on the south side roof expansion joints, 165 ft. apart. These skylights have heavy trough-shaped glass panes set in reinforced-concrete ribs and are made by the Keppler Glass Constructions, of New York. For ventilation of the space over the platforms there is at each bent a cast-iron flue with a 12-in. copper siphonage ventilator made by the Kernchen Co., of Chicago.

The smoke ducts are of special design, having the faces curved inward instead of being vertical. The base width is 3 ft., which is ample to allow for lateral motion of the engines. The 21-in. top width is designed to prevent driving rain from reaching the platforms, while at the same time giving free exit for the blast, so that there will be no back pressure causing smoke and cinders to escape inside the roof. The sides of the train-shed have concrete curtain walls. Large wire-glass windows provide light and have movable sash for ventilation.

Gravel Roads Are Economical Construction in Michigan

By Frank F. Rogers*

The popularity of gravel roads in Michigan is indicated by the fact that this type comprises 2,535 mi., or 60% of the total improved road mileage of the state, and this is due to the following reasons:

1. Gravel roads, constructed according to the specifications of the State Highway Department, draw a relatively large state reward—frequently one-third or more of their cost.

2. Suitable gravel is usually available locally, the expense is chiefly for labor, and all money spent in construction is kept at home.

3. Gravel roads are easily built and repaired, requiring no expensive machinery.

4. The first cost is low.

5. They are durable and can be maintained satisfactorily at a low cost in sections where the volume of the traffic is not beyond the capacity of the type of road.

Under the highway laws now in force in Michigan, state aid is extended to counties and townships in the shape of rewards paid to the local authorities on each mile of road built according to the specifications of the State Highway Department. There are seven classes of roads, varying from earth roads of a certain standard to concrete and brick-paved roads. The rewards vary from $250 to $1,700 per mi., which amounts are doubled if the road built forms a part of the state trunk-line system. The minimum width of road that it is permissible to build is 9 ft. A gravel road built in accordance with the state's specifications can command a reward of from $500 to $1,700 per mi., depending upon its width and location.

Why Gravel Roads Are Favored

It should not be inferred that the Michigan State Highway Department is in favor of any one type of road. In a system so large as to serve a whole state, every type of road has its place. However, large deposits of gravel suitable for road metal exist throughout the state, and its utilization in localities where the traffic is not so excessive as to cause high maintenance expense is in accordance with the best engineering practice.

The bank gravels of Michigan are of glacial origin and vary widely in character from those in the upper peninsula and northern part of the state, which contain a large proportion of limestone pebbles, to the gravels in the southern part, which are largely derived from such igneous rocks as granite and trap, and quartzite. Experience has shown that Michigan gravels are valuable for road purposes as follows:

1. Almost in direct proportion to the percentage of pebbles constituting the mass.

2. In direct proportion to the value as road material of the rock fragments constituting the pebbles.

3. In direct proportion to the value as a cementing material, under all conditions of weather, of the finer particles of earth matter constituting the filler or binder.

There is a tendency to place too much stress upon the immediate packing qualities of the gravel, and the fact is lost sight of that the only thing which makes a gravel road better than an earth road is the pebbles, or stone, that it contains. The material most sought after as a binder in road gravel is clay. If this is present much in excess of 10%, however, the road will become muddy whenever there is a prolonged wet period. Ideal clay gravel should contain only enough clay to coat the pebbles with no free lumps.

Conforming to these principles the requirement in the specifications is that at least 60% by weight, a larger percentage if possible, of the gravel shall be pebbles more than ⅛ in. in size, with no pebbles in the bottom layer that will not pass through a 2½-in. screen, none in the top layer that will not pass through a 1½-in. screen, and that not more than 10% of the mass shall be clay, uniformly mixed and having no free lumps.

Specifications for Gravel Roads

The specifications of the Michigan State Highway Department for state-reward gravel roads provide for the construction essentially as follows: Before building any state-reward road, the plan and profile of the road must be submitted to and approved by the State Highway Commissioner. No grades may exceed 6%. The road is graded to conform strictly to the plans and specifications, with due attention given to drainage. Shoulders are formed on either side of the roadway to retain the gravel within the width and depth specified. The subgrade is rolled until it is firm, and is 8 in. below and possesses the same crown as the finished grade.

The gravel, the specifications for which have already been given, is spread in two courses, the bottom and top courses being respectively 6 in. and 4 in. deep, loose measure, forming a total compacted depth of 8 in. In both courses all depressions and ruts that form during construction are filled, and each course in turn is thoroughly harrowed and rolled until it is everywhere hard and smooth, and the finished surface conforms to the proposed grade and cross-section. The importance of complete harrowing is emphasized. The ordinary spiked-toothed harrow is a tool second to none for compacting the gravel. The rolling is done after the gravel has been thoroughly wetted by sprinkling or rains.

Turning now to a discussion of the cost, we find a great diversity of plant used and a wide range of conditions from suburban streets to roads through uncut forests. An average cost based on 59 jobs, aggregating 68.42 mi. of 9-ft. gravel roads is about $2,500 per mi. With a quarter-mile haul the cost was $2,340, and with a 5-mi. haul, $2,850.

No matter how painstaking the work of construction may be, the final set of the gravel on the ordinary country road will come only under travel, and to insure a good surface the road must be kept smooth during the formative period. For this purpose the most effective tools are the plank and log drags, or some of the various types of steel drags that accomplish the same purpose.

These drags should be systematically used after rains, when the gravel is in a packing condition, and in the subsequent maintenance of the road. When once compacted and maintained in a manner that gives perfect surface drainage a gravel road may be expected to carry from 200 to 500 vehicles per day with an annual maintenance charge of from $100 to $200 per mi.

To conclude, the experience in Michigan has been that gravel is a satisfactory road material from many standpoints for roads of moderate traffic. It would seem that there are many locations throughout the country where a properly constructed gravel road would fulfill the requirements of a truly economical road.

*State Highway Commissioner, Lansing, Mich.

Long-Time New York Rainfall as Basis for Sewer Design--I

By O. Hufeland*

SYNOPSIS—Tabulations and diagrams of the New York City rainfall for the years 1869 to 1913 inclusive, were made, no storms being used in which the rate of precipitation was less than 1 in. per hour for a period of 10 min. The tabulations were made both by the "average-rate" and the "uniform-intensity" methods. The object is to show the widely different results obtained by the two methods and to point out that the "average-rate" method is seriously misleading when used in sewer design.

The data here discussed were taken from the rainfall charts of the Central Park observatory in New York City, for the period from April, 1869, to December, 1913. The apparatus used was the Draper recording rain gage in which the charts are secured to a vertical drum that makes one revolution in 24 hr. and the recording pen is attached to a tipping bucket which, as it fills, carries the pen down across the chart against the action of a spring until the bucket contains ½ in. of rainfall. It then tips and the spring brings back the empty bucket to its original position for a repetition of the operation. Each line across the chart made by the pen indicates ½ in. of rainfall, while the rotation of the drum gives the period during which this half inch or fraction of it fell. The vertical motion, 5¼ in., is sufficiently great clearly to indicate the quantity, but the time space of a little less than ½ in. for an hour is rather short for exact reading. However, some study of the charts permitted readings of sufficient accuracy to make the records of great value.

The charts for every day of the whole 45 yr. were carefully examined, and those which indicated a rate of intensity of 1 in. per hr. for 10 min. were selected for a preliminary study. These showed that the lower intensities for short periods were so frequent that they need not be considered in sewer design, and a series of minimum intensities was selected that were believed to be safely within the requirements of the purpose. These will be given later on. In this article the word "rainfall" indicates the quantity of rain that fell in any given period and the word "rate" means the rate in inches per hour at which it fell.

Figures above the minimum were tabulated by two different methods—the "average rate" and the "uniform intensity." I will first give the one that has been most used.

"Average-Rate" Method of Tabulation

Table 1 shows maximum accumulations of rainfall for selected periods, with average rates for such periods and the dates on which the storms occurred. Accumulated rainfall for whole storms was not sought except as it met the conditions of the tabulation. The figures in this table were obtained by selecting from the record chart of each storm the maximum rainfall for periods beginning with 5 min. and ending with 120 min. From the 5- to the 20-min. periods, 5-min. intervals were used; from 20 to 60 min., 10 min.; and from 60 to 120 min., 20-min. intervals. The rate was obtained by dividing the total quantity of rainfall for the selected period by the time. For the shortest period (5 min.), rates below 3 in. per hr. are omitted; for 10 and 15 min., below 2 in.; for 20 min., 1½ in.; and for the others 1 in. per hr. is the minimum, the rates below these figures occurring too frequently to need consideration. The table shows a gradual increase in quantity of rainfall for the successive periods in each storm, but these periods need

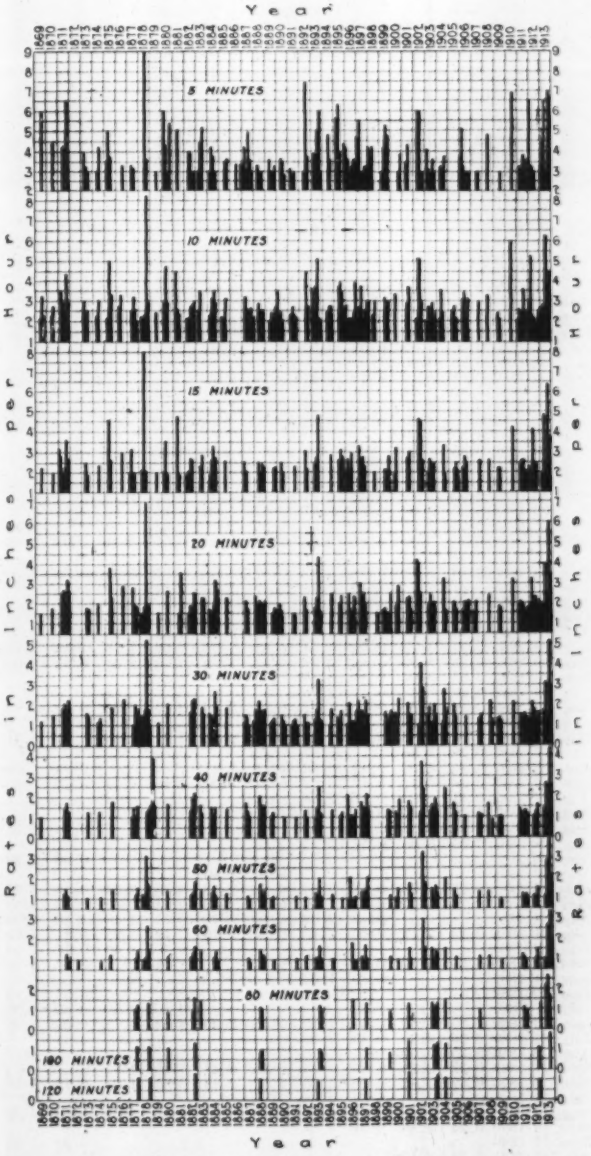


FIG. 1. FREQUENCY AND RATES OF RAINFALL, NEW YORK CITY, 1869 TO 1913; "AVERAGE-RATE" METHOD

*Assistant Engineer, Consulting Engineer's Office, Borough of Manhattan, Municipal Building, New York City.

TABLE 1. STUDY OF RAINFALL AT NEW YORK CITY, 1869 TO 1913, BY "AVERAGE RATE" METHOD

Maximum Accumulations of Rainfall in Inches for Periods from 5 to 120 Min., with Average Rates in Inches per Hour and Dates of Occurrence

		5 Min.		10 Min.		15 Min.		20 Min.		30 Min.		40 Min.		50 Min.		60 Min.		80 Min.		100 Min.		120 Min.	
Date	Year	Rain-fall	Rate	Rain-fall	Rate	Rain-fall	Rate	Rain-fall	Rate	Rain-fall	Rate	Rain-fall	Rate	Rain-fall	Rate	Rain-fall	Rate	Rain-fall	Rate	Rain-fall	Rate	Rain-fall	Rate
June 21	1869	....	....	0.35	2.10	....	....	0.50	1.50	0.60	1.20	0.68	1.02	....	....	....	....	....	....	....	....	....	....
Aug. 13	1869	0.49	5.88	0.52	3.12	0.56	2.24	0.57	1.71	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 15	1869	0.49	5.88	0.37	2.22	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
June 27	1870	....	....	0.37	2.22	0.50	2.00	0.59	1.77	0.76	1.52	....	....	....	....	....	....	....	....	....	....	....	....
July 28	1870	0.36	4.32	0.45	2.70	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
June 7	1871	0.35	4.20	0.59	3.54	0.78	3.12	0.86	2.58	0.91	1.82	0.96	1.44	1.01	1.21	....	....	....	....	....	....	....	....
July 16	1871	0.25	3.00	0.50	3.00	0.72	2.88	0.88	2.64	1.02	2.04	1.15	1.72	1.22	1.46	1.30	1.30	....	....	....	....	....	....
Aug. 16	1871	....	....	....	....	0.50	2.00	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Sept. 26	1871	....	....	0.38	2.28	0.57	2.28	0.68	2.04	0.81	1.62	0.89	1.34	0.94	1.13	0.97	0.97	....	....	....	....	....	....
Oct. 11	1871	0.54	6.48	0.73	4.38	0.90	3.60	1.06	3.18	1.10	2.20	....	....	....	....	1.14	1.14	....	....	....	....	....	....
Oct. 26	1871	0.27	3.24	0.49	2.94	0.72	2.88	0.87	2.61	0.91	1.82	....	....	....	....	....	....	....	....	....	....	....	....
July 25	1872	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1.00	1.00	....	....	....	....	....	....
July 5	1873	0.33	3.96	0.50	3.00	0.62	2.48	0.70	2.10	0.77	1.54	0.82	1.23	0.86	1.03	....	....	....	....	....	....	....	....
July 27	1873	0.27	3.24	0.38	2.28	0.48	1.92	0.58	1.74	0.70	1.40	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 21	1873	0.25	3.00	0.41	2.46	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
July 10	1874	0.25	3.00	0.37	2.22	0.41	1.64	0.45	1.35	0.57	1.14	0.84	1.26	0.85	1.04	0.98	0.98	....	....	....	....	....	....
July 12	1874	0.35	4.20	0.50	3.00	0.60	2.40	0.66	1.98	0.67	1.34	....	....	....	....	....	....	....	....	....	....	....	....
June 22	1875	....	3.48	0.35	2.40	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
July 26	1875	0.41	5.00	0.83	5.00	1.14	4.56	1.27	3.81	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 18	1875	0.31	3.72	0.55	3.30	0.66	2.64	0.77	2.31	0.92	1.84	1.16	1.74	1.22	1.47	1.25	1.25	....	....	....	....	....	....
May 26	1876	....	....	0.45	2.70	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 16	1876	0.28	3.36	0.54	3.24	0.75	3.00	0.96	2.88	1.14	2.28	....	....	....	....	....	....	....	....	....	....	....	....
June 21	1877	....	....	....	....	....	....	....	....	0.50	1.00	0.68	1.02	....	....	....	....	....	....	....	....	....	....
July 3	1877	0.28	3.36	0.43	2.58	0.50	2.00	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
July 17	1877	0.27	3.20	0.53	3.18	0.78	3.12	0.92	2.76	1.00	2.00	1.00	1.50	1.00	1.20	1.09	1.09	1.38	1.04	....	....	....	....
Aug. 14	1877	....	....	....	....	0.50	2.00	0.64	1.92	0.70	1.40	0.76	1.14	....	....	....	....	....	....	....	....	....	....
Aug. 25	1877	0.23	2.76	0.43	2.58	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Oct. 4	1877	....	....	0.33	2.00	0.50	2.00	0.63	1.86	0.90	1.80	1.06	1.59	1.27	1.52	1.50	1.50	1.70	1.28	2.00	1.20	2.15	1.08
June 21	1878	....	....	....	....	....	....	0.50	1.50	0.68	1.36	0.86	1.29	0.96	1.15	1.00	1.00	....	....	....	....	....	....
July 10	1878	....	....	0.36	2.16	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
July 21	1878	....	....	0.35	2.10	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
July 31	1878	....	....	....	....	....	....	0.50	1.50	0.74	1.48	0.93	1.39	....	....	....	....	....	....	....	....	....	....
Aug. 1	1878	....	....	0.37	2.22	0.54	2.16	0.61	1.83	0.86	1.72	1.06	1.59	1.01	1.21	1.12	1.12	....	....	....	....	....	....
Aug. 5	1878	0.75	9.00	1.37	8.22	2.00	8.00	2.31	6.93	2.61	5.22	2.62	3.93	2.64	3.17	2.66	2.66	....	....	....	....	....	....
Sept. 4	1878	0.30	3.60	0.48	2.88	0.52	2.08	0.64	1.92	0.86	1.72	1.06	1.59	1.43	1.72	1.50	1.50	1.80	1.35	2.00	1.20	2.20	1.10
Nov. 27	1878	....	....	....	....	....	....	....	....	0.50	1.00	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 25	1878	0.25	3.00	0.40	2.40	0.50	2.00	0.51	1.53	0.54	1.08	....	....	....	....	....	....	....	....	....	....	....	....
July 12	1880	0.50	6.00	0.79	4.74	0.86	3.44	0.87	2.61	1.02	2.04	1.08	1.62	1.16	1.39	1.17	1.17	1.23	0.92	1.85	1.11	....	....
July 27	1880	0.36	4.32	0.50	3.00	0.51	2.04	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 10	1880	0.25	3.00	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 20	1880	0.45	5.40	0.48	2.88	0.49	1.96	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
May 22	1881	0.42	5.04	0.75	4.50	1.17	4.68	1.19	3.57	....	....	....	....	....	....	....	....	....	....	....	....	....	....
July 4	1881	0.35	4.20	0.43	2.58	0.48	1.92	0.51	1.53	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 7	1881	0.35	4.20	0.38	2.28	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
June 15	1882	0.33	4.00	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
June 19	1882	0.33	4.00	....	....	....	....	0.50	1.50	....	....	....	....	....	....	....	....	....	....	....	....	....	....
June 26	1882	....	....	....	....	0.48	1.92	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Sept. 11	1882	....	....	0.35	2.10	0.48	1.92	0.62	1.86	0.81	1.62	0.92	1.38	1.01	1.21	1.10	1.10	1.25	0.94	....	....	....	....
Sept. 20	1882	0.33	3.96	0.46	2.76	0.52	2.08	0.58	1.74	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Sept. 22	1882	0.25	3.00	0.47	2.82	0.67	2.68	0.85	2.55	1.11	2.22	1.25	1.87	1.28	1.53	1.34	1.34	....	....	....	....	....	....
Sept. 23	1882	0.25	3.00	0.50	3.00	0.66	2.64	0.82	2.46	1.15	2.30	1.45	2.18	1.58	1.90	1.74	1.74	2.16	1.62	2.27	1.36	2.62	1.31
May 21	1883	0.25	3.00	0.42	2.52	0.58	2.32	0.77	2.31	0.93	1.86	1.03	1.55	1.18	1.42	1.51	1.51	1.93	1.44	....	....	....	....
June 6	1883	0.37	4.44	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
July 13	1883	0.43	5.16	0.58	3.48	0.67	2.84	0.75	2.25	0.78	1.56	0.81	1.21	....	....	....	....	....	....	....	....	....	....
June 25	1884	....	....	0.33	1.98	0.48	1.92	0.56	1.68	0.78	1.56	1.00	1.50	1.10	1.32	1.18	1.18	....	....	....	....	....	....
July 4	1884	0.25	3.00	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
July 12	1884	0.25	3.00	0.38	2.28	0.46	1.84	0.50	1.50	0.71	1.42	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 5	1884	0.35	4.20	0.53	3.18	0.62	2.48	0.65	1.95	0.68	1.36	0.71	1.07	0.73	0.88	....	....	....	....	....	....	....	....
Aug. 22	1884	0.31	3.72	0.59	3.54	0.81	3.24	1.06	3.18	1.35	2.70	....	....	....	....	1.45	1.45	....	....	....	....	....	....
Aug. 30	1884	0.25	3.00	0.48	2.88	0.68	2.72	0.88	2.64	0.95	1.90	0.97	1.45	0.99	1.19	1.01	1.01	....	....	....	....	....	....
June 5	1885	0.25	3.00	0.36	2.16	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
July 29	1885	0.29	3.48	0.35	2.10	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 3	1885	0.30	3.60	0.52	3.12	0.64	2.56	0.75	2.25	0.92	1.82	0.93	1.39	1.06	1.27	....	....	....	....	....	....	....	....
Nov. 18	1886	0.28	3.36	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
May 31	1887	0.28	3.36	0.53	3.18	0.63	2.52	0.71	2.13	0.77	1.54	1.12	1.68	....	....	....	....	....	....	....	....	....	....
June 17	1887	0.28	3.36	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
June 20	1887	0.35	4.20	0.43	2.58	0.46	1.84	....	....	0.54	1.08	....	....	....	....	....	....	....	....	....	....	....	....
June 22	1887	0.26	3.12	0.42	2.52	0.51	2.04	0.58	1.74	0.70	1.40	0.80	1.20	0.96	1.15	1.08	1.08	....	....	....	....	....	....
Aug. 18	1887	0.41	4.92	0.43	2.58	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 21	1887	0.30	3.60	0.35	2.10	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 22	1887	....	....	....	....	....	....	....	....	0.50	1.00	0.64	0.96	0.80	0.96	0.92	0.92	....	....	....	....	....	....
Aug. 24	1887	0.25	3.00	0.36	2.16	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
May 28	1888	....	....	....	....	....	....	....	....	0.60	1.20	....	....	....	....	....	....	....	....	....	....	....	....
May 29	1888	....	....	....	....	0.40	1.60	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
June 26	1888	0.27	3.30	0.47	2.82	0.62	2.48	0.78	2.34	0.89	1.78	....	....	....	....	....	....	....	....	....	....	....	....
July 19	1888	0.25	3.00	0.41	2.46	0.52	2.08	0.54	1.62	0.56	1.12	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 4	1888	....	....	0.42	2.52	0.60	2.40	0.71	2.13	1.10	2.20	1.36	2.04	1.41	1.69	1.45	1.45	1.50	1.12	.56	0.94	2.03	1.02
Aug. 21	1888	0.23	2.76	0.40	2.40	0.57	2.28	0.66	1.98	0.81	1.62	0.96	1.44	1.06	1.27	1.21	1.21	1.46	1.09	1.67	1.00	....	....
Sept. 8	1888	....	....	....	....	....	....	0.50	1.50	0.77	1.54	....	....	....	....	....	....	....	....	....	....	....	....
Sept. 20	1888	0.25	3.00	0.50	3.00	....	....	0.71	2.13	0.88	1.76	1.03	1.54	1.10	1.32	1.21	1.21	....	....	....	....	....	....
June 11	1889	....	....	0.33	1.98	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
June 15	1889	....	....	....	....	....	....	....	....	0.55	1.10	....	....	....	....	....	....	....	....	....	....	....	....
July 27	1889	....	....	....	....	....	....	0.50	1.50	0.60	1.20	0.71	1.07	0.82	0.98	....	....	....	....	....	....	....	....
July 30	1889	0.30	3.60	0.40	2.40	0.55	2.20	0.57	1.71	0.68	1.36	0.83	1.24	0.92	1.10	1.00	1.00	....	....	....	....	....	....
July 31	1889	0.25	3.00	0.35	2.10	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 2	1889	0.25	3.00	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Sept. 17	1889	0.27	3.24	0.45	2.70	0.56	2.24	0.55	1.65	....	....	....	....	....	....	....	....	....	....	....	....	....	....
June 6	1890	0.30	3.60	0.58	3.48	0.62	2.48	0.66	1.98	0.75	1.50	....	....	....	....	....	....	....	....	....	....	....	....
July 17	1890	....	....	0.38	2.28	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 22	1890	0.29	3.48	0.40	2.40	0.49	1.96	0.54	1.62	0.60	1.20	0.67	1.00	....	....	....	....	....	....	....	....	....	....
Sept. 16	1890	0.24	2.88	0.34	2.04	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Sept. 17	1890	....	....	....	....	....	....	....	....	0.50	1.00	....	....	....	....	....	....	....	....	....	....	....	....
Apr. 23	1891	0.26	3.12	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
June 17	1891	0.24	2.88	0.38	2.28	....	....	....	....	0.50	1.00	....	....	....	....	....	....	....	....	....	....	....	....
July 23	1891	0.25	3.00	0.44	2.64	0.58	2.32	0.50	1.50	0.60	1.20	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 23	1891	....	....	0.38	2.28	....	....	0.50	1.50	0.61	1.22	0.67	1.00	0.95	1.14	1.04	1.04	....	....	....	....	....	....
Sept. 5	1891	....	....	0.36	2.16	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
June 9	1892	0.25	3.00	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
July 3	1892	0.62	7.44	0.74	4.44	0.76	3.04	0.77	2.31	0.77	1.54	0.85	1.27	0.91	1.09	1.13	1.13	....	....	....	....	....	....
Aug. 9	1892	....	....	....	....	....	....	....	....	0.53	1.06	0.65	0.97	....	....	....	....	....	....	....	....	....	....
Sept. 13	1892	0.31	3.72	0.45	2.70	0.54	2.18	0.55	1.65	0.56	1.12	....	....	....	....	....	....	....	....	....	....	....	....
June 6	1893	0.32	3.84	0.60	3.60	0.61	2.44	0.62	1.86	0.64	1.28	0.65	0.97	1.05	1.26	1.08	1.08	....	....	....	....	....	....
July 26	1893	0.32	3.84	0.40	2.40	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 19	1893	0.42	5.04	0.62	3.72	0.69	2.76	0.75	2.25	0.87	1.74	0.94	1.41	1.00	1.20	1.07	1.07	....	....	....	....	....	....
Aug. 20	1893	0.50	6.00	0.85	5.10	1.20	4.80	1.45	4.35	1.65	3.30	1.66	2.49	1.67	2.00	1.68	1.68	1.76	1.17	1.79	1.07	1.84	0.92
Aug. 23	1893	....	....	....	....	....	....	....	....	0.60	1.20	0.76	1.14	0.90	1.08	1.05	1.05	1.30	0.97	1.57	0.94	1.74	0.87
Sept. 7	1893	....	....	0.35	2.10	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Oct. 27	1893	0.25	3.00	0.33	1.98	....	....	0.50	1.50	0.54	1.08	....	....	....	....	....	....	....	....	....	....	....	....
July 29	1894	....	....	0.40	2.40	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 3	1894	0.40	4.80	0.45	2.70	....	....	....	....	0.50	1.00	....	....	....	....	....	....	....	....	....	....	....	....
Sept. 8	1894	0.30	3.60	0.45	2.70	0.71	2.84	0.84	2.52	0.89	1.78	0.89	1.33	1.00	1.20	1.03	1.03	....	....	....	....	....	....
Sept. 16	1894	0.30	3.60	0.38	2.28	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

TABLE 1. STUDY OF RAINFALL AT NEW YORK CITY, 1869 TO 1913, BY "AVERAGE-RATE" METHOD—Continued

Maximum Accumulations of Rainfall in Inches for Periods from 5 to 120 Min., with Average Rates in Inches per Hour and Dates of Occurrence

		5 Min.		10 Min.		15 Min.		20 Min.		30 Min.		40 Min.		50 Min.		60 Min.		80 Min.		100 Min.		120 Min.	
Date	Year	Rain-fall	Rate	Rain-fall	Rate	Rain-fall	Rate	Rain-fall	Rate	Rain-fall	Rate	Rain-fall	Rate	Rain-fall	Rate	Rain-fall	Rate	Rain-fall	Rate	Rain-fall	Rate	Rain-fall	Rate
June 5	1895	0.47	5.64	0.62	3.72	0.65	2.60	0.67	2.01	0.69	1.38	0.71	1.06	....	....	....	....	....	....	....	....	....	....
Aug. 4	1895	....	....	....	....	....	....	....	....	0.58	1.16	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 6	1895	0.53	6.35	0.66	3.96	0.78	3.12	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 31	1895	0.33	3.96	0.57	3.42	0.70	2.80	0.79	2.37	0.82	1.64	0.85	1.27	0.87	1.04	....	....	....	....	....	....	....	....
May 28	1896	....	....	....	....	....	....	....	....	0.52	1.04	....	....	....	....	....	....	....	....	....	....	....	....
June 10	1896	0.36	4.32	0.44	2.64	0.50	2.00	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
July 6	1896	0.35	4.20	0.45	2.70	0.66	2.64	0.82	2.46	1.06	2.12	1.38	2.07	1.70	2.04	1.85	1.85	1.95	1.46	....	....	....	....
July 15	1896	0.30	3.60	0.33	2.00	....	....	0.50	1.50	0.52	1.04	0.65	0.97	0.80	0.96	....	....	....	....	....	....	....	....
July 20	1896	0.25	3.00	0.35	2.10	....	....	....	....	0.61	1.22	0.71	1.06	....	....	....	....	....	....	....	....	....	....
July 22	1896	0.27	3.24	0.34	2.04	0.50	2.00	0.58	1.74	0.60	1.20	0.66	0.98	0.89	1.07	0.92	0.92	....	....	....	....	....	....
July 30	1896	....	....	0.40	2.40	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Sept. 3	1896	0.30	3.60	0.65	3.90	0.73	2.92	0.77	2.31	0.85	1.70	0.90	1.35	0.92	1.10	0.94	0.94	....	....	....	....	....	....
Sept. 15	1896	0.30	3.60	0.34	2.04	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Sept. 18	1896	0.39	4.68	0.44	2.64	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
May 24	1897	0.46	5.52	0.62	3.72	0.81	3.24	1.01	3.03	1.10	2.20	1.15	1.72	1.16	1.39	1.18	1.18	....	....	....	....	....	....
June 9	1897	0.24	2.88	0.35	2.10	....	....	....	....	0.64	1.28	0.84	1.26	0.92	1.10	1.02	1.02	....	....	....	....	....	....
July 21	1897	0.25	3.00	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
July 23	1897	0.27	3.24	0.42	2.52	0.67	2.68	0.79	2.37	0.86	1.72	0.92	1.38	1.02	1.22	1.06	1.06	....	....	....	....	....	....
July 28	1897	....	....	....	....	....	....	....	....	0.50	1.00	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 23	1897	0.25	3.00	0.50	3.00	0.69	2.76	0.85	2.55	1.11	2.22	1.40	2.10	1.70	2.04	1.74	1.74	1.78	1.33	1.82	1.09	1.92	0.96
Sept. 1	1897	0.35	4.20	0.50	3.00	0.58	2.32	0.65	1.95	0.72	1.44	0.76	1.14	....	....	....	....	....	....	....	....	....	....
Apr. 24	1898	0.30	3.60	0.38	2.28	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
July 4	1898	0.35	4.20	0.50	3.00	0.50	2.00	0.51	1.53	....	....	....	....	....	....	....	....	....	....	....	....	....	....
June 15	1899	....	....	....	....	....	....	....	....	0.81	1.62	....	....	....	....	....	....	....	....	....	....	....	....
June 28	1899	0.25	3.00	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
July 12	1899	0.35	4.20	0.53	3.18	0.54	2.16	0.55	1.65	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 10	1899	0.44	5.28	0.46	2.76	0.49	1.96	0.52	1.56	0.59	1.18	....	....	....	....	....	....	....	....	....	....	....	....
Sept. 1	1899	....	....	....	....	....	....	0.50	1.50	0.71	1.42	0.90	1.35	1.00	1.20	1.20	1.20	1.27	0.95	1.50	0.90	....	....
Sept. 3	1899	0.40	4.80	0.50	3.00	0.70	2.80	0.82	2.46	0.85	1.70	0.87	1.30	....	....	....	....	....	....	....	....	....	....
May 19	1900	....	....	....	....	0.48	1.92	0.62	1.86	0.79	1.58	0.83	1.24	0.88	1.06	1.04	1.04	....	....	....	....	....	....
Aug. 12	1900	0.25	3.00	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 26	1900	0.32	3.84	0.55	3.30	0.80	3.20	0.94	2.82	1.15	2.30	1.23	1.84	1.26	1.51	....	....	....	....	....	....	....	....
July 5	1901	0.29	3.48	0.48	2.88	0.68	2.72	0.75	2.25	1.05	2.10	1.18	1.77	1.45	1.74	1.60	1.60	1.81	1.36	2.40	1.44	2.65	1.32
July 6	1901	0.36	4.32	0.61	3.66	0.75	3.00	0.76	2.28	0.77	1.54	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 24	1901	....	....	....	....	....	....	0.56	1.68	0.77	1.54	0.96	1.44	1.03	1.24	1.08	1.08	....	....	....	....	....	....
June 21	1902	....	....	....	....	....	....	....	....	0.50	1.00	0.67	1.00	....	....	....	....	....	....	....	....	....	....
July 20	1902	....	....	0.35	2.10	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
July 28	1902	0.50	6.00	0.86	5.16	1.15	4.60	1.40	4.20	2.04	4.08	2.46	3.69	2.77	3.32	3.02	3.02	....	....	....	....	....	....
Aug. 5	1902	0.50	6.00	0.86	5.16	1.13	4.52	1.35	4.05	1.45	2.90	1.57	2.35	1.59	1.81	1.61	1.61	....	....	....	....	....	....
Feb. 28	1903	0.34	4.08	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
June 14	1903	....	....	0.33	1.98	0.50	2.00	0.65	1.95	0.71	1.42	0.85	1.27	....	....	....	....	....	....	....	....	....	....
June 21	1903	0.26	3.12	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
June 29	1903	0.24	2.88	0.45	2.70	0.65	2.60	0.80	2.40	0.91	1.82	1.04	1.56	1.27	1.52	1.55	1.55	1.85	1.36	2.00	1.20	2.10	1.05
July 2	1903	....	....	0.40	2.40	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
July 22	1903	0.30	3.60	0.48	2.88	0.50	2.00	0.50	1.50	0.52	1.04	....	....	....	....	....	....	....	....	....	....	....	....
Sept. 16	1903	....	....	....	....	....	....	....	....	0.53	1.06	0.70	1.05	0.95	1.14	1.03	1.03	1.26	0.94	....	....	....	....
Sept. 17	1903	....	....	0.33	1.98	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Oct. 8	1903	0.25	3.00	0.40	2.40	0.60	2.40	0.68	2.04	1.00	2.00	1.25	1.87	1.36	1.63	1.44	1.44	1.64	1.23	1.71	1.03	....	....
Oct. 9	1903	....	....	....	....	....	....	....	....	0.75	1.50	0.89	1.33	1.08	1.30	1.35	1.35	1.82	1.36	2.15	1.29	2.42	1.21
May 30	1904	....	....	0.35	2.10	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
July 11	1904	....	....	....	....	....	....	....	....	0.50	1.00	....	....	....	....	....	....	....	....	....	....	....	....
July 28	1904	0.27	3.24	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 4	1904	0.25	3.00	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 19	1904	0.31	3.72	0.59	3.54	0.82	3.28	1.07	3.21	1.38	2.76	1.60	2.40	1.66	1.99	1.72	1.72	1.96	1.47	2.05	1.23	2.15	1.07
Sept. 14	1904	....	....	0.40	2.40	0.48	1.92	0.54	1.62	0.63	1.26	....	....	....	....	....	....	....	....	....	....	....	....
June 22	1905	....	....	0.41	2.46	0.55	2.20	0.68	2.04	0.98	1.96	1.11	1.66	1.19	1.43	....	....	....	....	....	....	....	....
Aug. 13	1905	....	....	0.45	2.70	0.61	2.44	0.65	1.95	0.70	1.40	0.76	1.14	0.95	1.14	1.11	1.11	....	....	....	....	....	....
Oct. 19	1905	....	....	0.36	2.16	0.52	2.08	0.55	1.65	....	....	....	....	....	....	....	....	....	....	....	....	....	....
May 5	1906	0.31	3.72	0.52	3.12	0.55	2.20	0.55	1.65	....	....	....	....	....	....	....	....	....	....	....	....	....	....
May 27	1906	0.42	5.04	0.57	3.42	0.68	2.72	0.69	2.07	....	....	....	....	....	....	....	....	....	....	....	....	....	....
July 10	1906	0.22	2.64	0.34	2.04	0.45	1.80	0.58	1.74	0.70	1.40	0.72	1.08	....	....	....	....	....	....	....	....	....	....
July 17	1906	0.27	3.24	0.52	3.12	0.61	2.44	0.70	2.10	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Sept. 13	1906	0.25	3.00	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 9	1907	0.25	3.00	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 24	1907	....	....	....	....	....	....	0.50	1.50	0.65	1.30	0.80	1.20	1.00	1.20	1.15	1.15	1.30	0.97	....	....	....	....
Sept. 11	1907	0.25	3.00	0.50	3.00	0.64	2.56	0.69	2.07	0.76	1.52	0.77	1.15	....	....	....	....	....	....	....	....	....	....
July 14	1908	0.40	4.80	0.55	3.30	0.65	2.60	0.80	2.40	1.10	2.20	1.14	1.71	1.15	1.38	1.16	1.16	....	....	....	....	....	....
Sept. 28	1908	....	....	....	....	....	....	....	....	0.55	1.10	0.65	0.97	....	....	....	....	....	....	....	....	....	....
June 28	1909	....	....	0.40	2.40	0.55	2.20	0.61	1.83	0.65	1.30	0.67	1.00	....	....	....	....	....	....	....	....	....	....
Aug. 4	1909	....	....	....	....	....	....	....	....	0.66	1.32	0.68	1.02	0.83	0.99	0.96	0.96	....	....	....	....	....	....
Aug. 13	1909	0.25	3.00	0.35	2.10	0.55	2.20	0.57	1.71	0.60	1.20	0.67	1.00	0.82	0.98	....	....	....	....	....	....	....	....
July 31	1910	....	....	1.00	6.00	1.05	4.20	1.07	3.21	1.08	2.16	....	....	....	....	....	....	....	....	....	....	....	....
Mar. 27	1911	0.27	3.24	0.33	1.98	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
June 10	1911	....	....	0.42	2.52	0.60	2.40	0.63	1.89	....	....	....	....	....	....	....	....	....	....	....	....	....	....
June 11	1911	0.25	3.00	0.40	2.40	0.65	2.60	0.68	2.04	0.77	1.54	0.93	1.39	1.04	1.25	1.28	1.28	1.40	1.05	....	....	....	....
July 20	1911	0.32	3.84	0.60	3.60	0.65	2.60	0.66	1.98	0.67	1.34	0.98	1.02	....	....	....	....	....	....	....	....	....	....
Aug. 15	1911	....	....	0.40	2.40	0.52	2.08	0.62	1.86	0.78	1.56	0.80	1.20	0.82	0.98	....	....	....	....	....	....	....	....
Aug. 24	1911	....	....	....	....	....	....	0.50	1.50	0.68	1.36	0.89	1.31	1.02	1.22	1.08	1.08	1.23	0.92	....	....	....	....
Oct. 19	1911	....	....	....	....	0.50	2.00	0.57	1.71	0.67	1.34	0.75	1.13	0.85	1.02	1.00	1.00	1.25	0.93	....	....	....	....
Feb. 27	1912	0.30	3.60	0.50	3.00	0.57	2.28	0.63	1.89	0.67	1.34	0.71	1.06	....	....	....	....	....	....	....	....	....	....
May 30	1912	0.55	6.60	0.88	5.28	1.03	4.12	1.07	3.21	1.08	2.16	....	....	....	....	....	....	....	....	....	....	....	....
June 17	1912	0.28	3.36	0.38	2.28	....	....	0.53	1.59	....	....	....	....	....	....	....	....	....	....	....	....	....	....
July 21	1912	0.27	3.24	0.36	2.16	0.62	2.48	0.77	2.31	0.89	1.78	0.91	1.36	0.94	1.13	0.96	0.96	....	....	....	....	....	....
Aug. 10	1912	0.25	3.00	0.34	2.04	....	....	0.56	1.68	0.62	1.24	....	....	....	....	....	....	....	....	....	....	....	....
Oct. 12	1912	....	....	0.41	2.46	0.60	2.40	0.70	2.10	0.81	1.62	1.07	1.61	1.32	1.58	1.53	1.53	1.73	1.30	1.89	1.13	1.93	0.96
June 20	1913	0.37	4.44	0.44	2.64	0.49	1.96	0.50	1.50	0.87	1.74	0.93	1.39	0.97	1.16	1.02	1.03	....	....	....	....	....	....
July 1	1913	....	....	....	....	....	....	0.65	1.95	....	....	....	....	....	....	....	....	....	....	....	....	....	....
July 24	1913	0.42	5.04	0.47	2.82	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
July 28	1913	0.54	6.48	1.05	6.30	1.22	4.88	1.31	3.93	1.58	3.16	1.80	2.70	2.40	2.88	2.68	2.68	2.94	2.20	....	....	....	....
Aug. 7	1913	0.25	3.00	0.40	2.40	0.53	2.12	0.65	1.95	0.67	1.34	0.76	1.14	....	....	....	....	....	....	....	....	....	....
Sept. 4	1913	0.60	7.20	1.18	6.90	1.60	6.40	2.00	6.00	2.56	5.12	2.95	4.42	3.20	3.84	3.40	3.40	3.60	2.70	....	....	....	....
Oct. 1	1913	0.56	6.72	0.75	4.50	0.93	3.72	1.15	3.45	1.49	2.98	1.73	2.59	1.78	2.14	1.90	1.90	2.20	1.65	3.14	1.88	....	....

not necessarily be connected. The maximum quantity for 5 min., for instance, may have fallen at one point of a storm, that for 10 min. at another and that for 15 min. at a third, and in none of them need the rainfall have been uniform, the rate given always being the average for the whole period. Or all of the foregoing may be connected to make the 30-min. period, and then the rate given would be the average of the total quantity that fell in the three periods at different rates.

In addition to the data described in the preceding paragraph, it is necessary to know how often the various intensities occurred. This information is given in Table 2, which shows how often each intensity occurred in each of the selected periods. In order to give a general view of the frequency, Figs. 1 and 2 have been prepared for every period from 5 to 120 min. for the whole 45 yr. On these the rates have been plotted in the order of their occurrence, so that the frequency of any rate for the period can be found by inspection. These diagrams also show a fact that is generally overlooked—namely, that a 3-in. rate for 5 min., for instance, instead of occurring only 39 times, as an inspection of the table would seem

TABLE 2. STUDY OF RAINFALL AT NEW YORK CITY, 1869 TO 1913, BY "AVERAGE-RATE" METHOD

Number of Recurrences of Rainfall and Rates for Periods from 5 to 120 Min., Arranged in the Order of Increasing Intensities

5 Min. Rate, 3 In. and Over		10 Min. Rate, 1.80 In. and Over		15 Min. Rate, 1.60 In. and Over		20 Min. Rate, 1.44 In. and Over		30 Min. Rate, 1 In. and Over		40 Min. Rate, 0.63 In. and Over		50 Min. Rate, 0.96 In. and Over		60 Min. Rate, 0.90 In. and Over		80 Min. Rate, 0.83 In. and Over		100 Min. Rate, 0.79 In. and Over		120 Min. Rate, 0.70 In. and Over	
Rain- No.	fall Rate	Rain- No.	fall Rate	Rain- No.	fall Rate	Rain- No.	fall Rate	Rain- No.	fall Rate	Rain- No.	fall Rate	Rain- No.	fall Rate	Rain- No.	fall Rate	Rain- No.	fall Rate	Rain- No.	fall Rate	Rain- No.	fall Rate
39	0.25 3.00	2	0.30 1.80	3	0.40 1.60	1	0.48 1.44	8	0.50 1.00	1	0.63 0.94	2	0.80 0.96	1	0.92 0.92	1	1.12 0.83	1	1.32 0.79	2	1.40 0.70
4	0.26 3.12	3	0.32 1.92	2	0.42 1.68	17	0.50 1.50	3	0.52 1.04	4	0.65 0.97	2	0.82 0.98	1	0.94 0.94	1	1.16 0.87	1	1.34 0.80	1	1.41 0.70
10	0.27 3.24	9	0.33 1.98	1	0.43 1.72	3	0.51 1.53	2	0.53 1.06	1	0.96 0.99	1	0.85 1.02	1	0.96 0.96	2	1.18 0.89	1	1.36 0.82	1	1.42 0.71
7	0.28 3.36	4	0.34 2.04	2	0.44 1.76	1	0.52 1.56	2	0.54 1.08	3	0.67 1.00	1	0.87 1.04	1	0.97 0.97	2	1.23 0.92	1	1.38 0.83	1	1.43 0.71
3	0.29 3.48	11	0.35 2.10	3	0.45 1.80	1	0.53 1.59	2	0.55 1.10	2	0.68 1.02	1	0.88 1.06	3	1.00 1.00	2	1.25 0.94	1	1.42 0.85	1	1.58 0.79
10	0.30 3.60	3	0.36 2.16	1	0.46 1.84	4	0.54 1.62	1	0.56 1.12	1	0.70 1.05	1	0.89 1.07	2	1.02 1.02	1	1.26 0.95	1	1.50 0.90	1	1.74 0.87
1	0.31 3.72	3	0.37 2.22	1	0.47 1.88	2	0.55 1.65	1	0.58 1.16	4	0.71 1.06	1	0.91 1.09	1	1.03 1.03	1	1.27 0.96	1	1.56 0.94	1	1.75 0.87
2	0.32 3.84	9	0.38 2.28	6	0.48 1.92	1	0.56 1.68	1	0.59 1.18	1	0.72 1.08	3	0.92 1.10	1	1.04 1.04	2	1.30 0.97	1	1.57 0.94	1	1.76 0.88
2	0.33 4.00	11	0.40 2.40	4	0.49 1.96	2	0.57 1.71	5	0.60 1.20	1	0.75 1.13	2	0.94 1.13	1	1.07 1.07	1	1.38 1.04	1	1.67 1.00	1	1.92 0.96
1	0.34 4.08	3	0.41 2.46	12	0.50 2.00	3	0.58 1.74	2	0.61 1.22	4	0.76 1.14	3	0.95 1.14	3	1.08 1.08	1	1.40 1.05	1	1.71 1.03	1	1.98 0.96
8	0.35 4.20	6	0.42 2.52	2	0.51 2.04	4	0.59 1.77	1	0.63 1.26	3	0.80 1.20	1	0.96 1.15	1	1.09 1.09	1	1.46 1.09	1	1.82 1.09	1	2.03 1.01
2	0.36 4.32	4	0.43 2.58	4	0.52 2.08	1	0.61 1.83	1	0.64 1.28	2	0.83 1.25	1	0.97 1.16	1	1.10 1.10	1	1.50 1.12	1	1.85 1.11	1	2.10 1.05
3	0.37 4.44	5	0.44 2.64	1	0.53 2.12	4	0.62 1.86	1	0.65 1.30	1	0.84 1.26	4	1.00 1.20	1	1.11 1.11	1	1.64 1.23	1	1.89 1.13	2	2.15 1.07
1	0.38 4.56	7	0.45 2.70	1	0.54 2.16	2	0.64 1.92	1	0.66 1.32	3	0.85 1.27	1	1.01 1.21	1	1.13 1.13	1	1.70 1.28	3	2.00 1.20	1	2.20 1.10
1	0.39 4.68	1	0.46 2.76	2	0.55 2.20	5	0.65 1.95	5	0.67 1.34	1	0.86 1.29	2	1.02 1.22	1	1.15 1.15	1	1.73 1.30	1	2.05 1.23	1	.242 1.21
5	0.40 4.80	2	0.47 2.82	2	0.56 2.24	4	0.66 1.98	3	0.68 1.36	3	0.89 1.34	1	1.03 1.24	1	1.16 1.16	1	1.78 1.33	1	2.15 1.29	1	.262 1.31
2	0.41 4.92	4	0.48 2.88	2	0.57 2.28	1	0.67 2.01	1	0.69 1.38	2	0.90 1.35	1	1.04 1.25	1	1.17 1.17	1	1.81 1.36	1	2.27 1.36	1	2.65 1.33
3	0.42 5.04	1	0.49 2.94	4	0.58 2.32	3	0.68 2.04	3	0.70 1.40	1	0.91 1.37	1	1.05 1.26	1	1.18 1.18	1	1.82 1.37	1	2.40 1.44		
1	0.44 5.28	10	0.50 3.00	4	0.60 2.40	2	0.69 2.07	2	0.71 1.42	2	0.92 1.38	1	1.06 1.27	1	1.20 1.20	1	1.85 1.39	1	3.14 1.88		
1	0.45 5.40	3	0.52 3.12	2	0.61 2.44	3	0.71 2.13	2	0.72 1.44	4	0.93 1.40	1	1.08 1.30	2	1.21 1.21	1	1.92 1.44				
1	0.46 5.52	4	0.53 3.18	1	0.62 2.48	1	0.72 2.16	1	0.74 1.48	1	0.94 1.41	1	1.10 1.32	1	1.28 1.28	1	1.95 1.46				
1	0.47 5.64	2	0.54 3.24	2	0.63 2.52	1	0.74 2.22	1	0.75 1.50	3	0.96 1.44	1	1.15 1.38	1	1.30 1.30	1	1.96 1.47				
1	0.49 5.88	2	0.55 3.30	3	0.64 2.56	3	0.75 2.25	1	0.76 1.52	1	1.00 1.50	2	1.16 1.39	1	1.35 1.35	1	2.16 1.62				
7	0.50 6.00	2	0.57 3.42	6	0.65 2.60	4	0.77 2.31	5	0.77 1.54	2	1.03 1.55	1	1.18 1.42	1	1.44 1.44	1	2.20 1.65				
1	0.53 6.36	1	0.58 3.48	3	0.66 2.64	3	0.79 2.37	1	0.78 1.56	1	1.04 1.56	1	1.19 1.43	1	1.45 1.45	1	2.94 2.20				
1	0.54 6.48	1	0.59 3.54	2	0.67 2.68	2	0.80 2.40	2	0.79 1.58	1	1.06 1.59	1	1.22 1.46	1	1.50 1.50	1	3.60 2.70				
1	0.58 6.96	3	0.60 3.60	2	0.68 2.72	2	0.82 2.46	5	0.81 1.62	1	1.07 1.61	2	1.27 1.52	1	1.51 1.51						
1	0.62 7.44	3	0.62 3.72	1	0.69 2.76	1	0.83 2.49	1	0.82 1.64	1	1.08 1.62	1	1.32 1.58	2	1.55 1.55						
1	0.65 7.80	1	0.65 3.90	2	0.70 2.80	2	0.85 2.55	1	0.85 1.70	1	1.09 1.64	1	1.36 1.63	1	1.60 1.60						
1	0.67 8.04	1	0.66 3.96	1	0.71 2.84	1	0.88 2.64	3	0.86 1.72	1	1.11 1.66	1	1.41 1.69	1	1.68 1.68						
1	0.75 9.00	1	0.70 4.20	1	0.72 2.88	1	0.92 2.76	2	0.87 1.74	1	1.12 1.68	1	1.43 1.72	1	1.72 1.72						
		1	0.73 4.38	2	0.73 2.92	1	0.96 2.88	1	0.88 1.76	1	1.14 1.71	1	1.45 1.74	1	1.74 1.74						
		2	0.75 4.50	1	0.75 3.00	1	1.00 3.00	1	0.89 1.78	1	1.15 1.72	1	1.58 1.90	1	1.85 1.85						
		1	0.77 4.62	1	0.76 3.04	1	1.01 3.03	1	0.90 1.80	1	1.16 1.74	1	1.66 1.99	1	1.90 1.90						
		1	0.78 4.68	4	0.78 3.12	1	1.06 3.18	2	0.91 1.82	1	1.18 1.77	1	1.67 2.00	1	2.66 2.66						
		1	0.79 4.74	1	0.81 3.24	1	1.07 3.21	2	0.92 1.84	2	1.25 1.88	2	1.70 2.04	1	2.68 2.68						
		1	0.83 4.98	1	0.82 3.28	1	1.15 3.45	1	0.93 1.86	1	1.36 2.04	1	1.78 2.14	1	3.02 3.02						
		2	0.86 5.16	1	0.86 3.44	1	1.26 3.78	1	0.98 1.96	1	1.38 2.07	1	2.40 2.88	1	3.40 3.40						
		1	0.95 5.70	1	0.90 3.60	1	1.27 3.81	2	1.00 2.00	1	1.40 2.10	1	2.64 3.17								
		1	1.00 6.00	1	0.93 3.72	1	1.31 3.93	1	1.02 2.04	1	1.45 2.18	1	2.77 3.32								
		1	1.02 6.12	1	1.03 4.12	1	1.35 4.05	1	1.05 2.10	1	1.60 2.40	1	3.20 3.84								
		1	1.20 7.20	1	1.05 4.20	1	1.40 4.20	1	1.06 2.12	1	1.66 2.49										
		1	1.37 8.22	1	1.13 4.52	1	1.45 4.35	3	1.10 2.20	1	1.73 2.60										
				1	1.14 4.56	1	2.00 6.00	2	1.11 2.22	1	1.80 2.70										
				1	1.15 4.60	1	2.31 6.93	1	1.14 2.28	1	2.46 3.69										
				1	1.17 4.68			2	1.15 2.30	1	2.62 3.93										
				1	1.22 4.88			1	1.45 2.90	1	2.95 4.38										
				1	1.25 5.00			1	1.49 2.98												
				1	1.60 6.40			1	1.50 3.00												
				1	2.00 8.00			1	1.58 3.16												
								1	1.65 3.30												
								1	2.04 4.08												
								1	2.56 5.12												
								1	2.61 5.22												

TABLE 3. STUDY OF RAINFALL AT NEW YORK CITY, 1869 TO 1913, BY "AVERAGE-RATE" METHOD

Nine Maximum Rates from Which "Rainfall Curves" Were Plotted with Interpolated Points for "10-Yr. Curve"

Date of Storm	5 Min.	Date of Storm	15 Min.	Date of Storm	30 Min.	Date of Storm	50 Min.	Date of Storm	80 Min.	Date of Storm	120 Min.
Aug. 5, 1878..	9.00	Aug. 5, 1878..	8.00	Aug. 5, 1878..	5.22	Sept. 4, 1913..	3.84	Sept. 4, 1913..	2.70	July 5, 1901..	1.33
Sept. 4, 1913..	8.04	Sept. 4, 1913..	6.40	Sept. 4, 1913..	5.12	July 28, 1902..	3.32	July 28, 1913..	2.20	Sept. 23, 1882..	1.31
July 3, 1892..	7.80	Aug. 4, 1893..	5.00	July 28, 1902..	4.08	Aug. 5, 1878..	3.17	Oct. 1, 1913..	1.65	Oct. 9, 1903..	1.21
May 30, 1912..	7.44	July 28, 1913..	4.88	Aug. 20, 1893..	3.30	July 28, 1913..	2.88	Sept. 23, 1882..	1.62	Sept. 4, 1878..	1.10
Interpolated 10 Yr.....	7.17	Interpolated 10 Yr.....	4.76	Interpolated 10 Yr...	3.32	Interpolated 10 Yr.....	2.47	Interpolated 10 Yr.....	1.54	Interpolated 10 Yr.....	1.09
July 31, 1912..	6.96	May 22, 1881..	4.68	July 28, 1913..	3.16	Oct. 1, 1913..	2.14	Aug. 19, 1904..	1.47	Oct. 4, 1877..	1.08
Oct. 11, 1871..	6.48	July 28, 1902..	4.60	Aug. 19, 1904..	3.00	Aug. 23, 1897..	2.04	July 6, 1896..	1.46	Aug. 19, 1904..	1.07
Aug. 6, 1893..	6.36	July 26, 1875..	4.56	Oct. 1, 1913..	2.98	July 6, 1896..	2.04	May 21, 1883..	1.44	June 29, 1903..	1.05
July 12, 1880..	6.00	Aug. 5, 1902..	4.52	Aug. 5, 1902..	2.90	Aug. 20, 1893..	2.00	June 29, 1903..	1.39	Aug. 4, 1888..	1.01
Oct. 1, 1913..	6.00	July 31, 1910..	4.20	Sept. 23, 1882..	2.30	Aug. 19, 1904..	1.99	Oct. 9, 1903..	1.37	Oct. 23, 1912..	0.96
10 Min.		**20 Min.**		**40 Min.**		**60 Min.**		**100 Min.**			
Aug. 5, 1878..	8.22	Aug. 5, 1878..	6.93	Sept. 4, 1913..	4.38	Sept. 4, 1913..	3.40	Oct. 1, 1913..	1.88		
Sept. 4, 1913..	7.20	Sept. 4, 1913..	6.00	Aug. 5, 1878..	3.93	July 28, 1902..	3.02	July 5, 1901..	1.44		
May 30, 1912..	6.12	Aug. 20, 1893..	4.35	July 28, 1902..	3.69	July 28, 1913..	2.68	Sept. 23, 1882..	1.36		
July 31, 1910..	6.00	July 28, 1902..	4.20	July 28, 1913..	2.70	Aug. 5, 1878..	2.66	Oct. 9, 1903..	1.29		
Interpolated 10 Yr.....	5.83	Interpolated 10 Yr.....	4.12	Interpolated 10 Yr.....	2.64	Interpolated 10 Yr.....	2.24	Interpolated 10 Yr.....	1.26		
July 28, 1913..	5.70	Aug. 5, 1902..	4.05	Oct. 1, 1913..	2.60	Oct. 1, 1913..	1.90	Aug. 19, 1904..	1.23		
Aug. 5, 1902..	5.16	July 28, 1913..	3.93	Aug. 20, 1893..	2.49	July 6, 1896..	1.85	June 29, 1903..	1.20		
July 28, 1902..	5.16	July 26, 1875..	3.81	Aug. 19, 1904..	2.40	Aug. 23, 1897..	1.74	Oct. 4, 1877..	1.20		
July 26, 1875..	4.98	Aug. 22, 1884..	3.78	Sept. 23, 1882..	2.18	Sept. 23, 1882..	1.74	Oct. 23, 1912..	1.13		
July 12, 1880..	4.74	Oct. 1, 1913..	3.45	Aug. 23, 1897..	2.10	Aug. 19, 1904..	1.72	July 12, 1880..	1.11		

to show, really occurs 123 times, because a 3-in. rate and more occurred with every higher intensity of the period; and that a 4-in. rate, instead of occurring only two times, occurred 47 times, etc. By counting the storms that cross the ordinate for the rate required (Fig. 1) the number of times when that rate was reached or exceeded in that period can be found. These diagrams, together with the tables, give a complete compilation of the rainfall records according to the "average rate" method.

From the data so obtained rainfall curves are developed which are supposed to show the frequency of maximum storms based on their past occurrence.

Fig. 2 shows such curves for intervals of from 5 to 45 yr. and for storms of from 5 to 120 min. duration. The curves are constructed in the following manner:

Table 3 shows the nine highest rates selected from each of the periods in Table 1. These were plotted into a like number of curves on coördinate paper, the abscissas representing time up to 120 min. and the ordinates rates in inches per hour. The highest rates recorded for each of the eleven periods from 5 to 120 min. form what is called the "45-Yr. Curve," because they occurred but once in that period. The second highest are similarly treated, and because they occurred twice in 45-yr., become the "22½-Yr. Curve"; the third because they

occurred three times form the "15-Yr. Curve" and so on to the ninth, which is supposed to give the intensities that occur once in 5 yr. To the nine curves so obtained from the tables another is added by interpolation, which is supposed to represent a "10-Yr. Curve." The equations opposite some of the curves represent the curves drawn through them in broken lines.

From this series of curves one is selected as a basis of sewer computation. If it is desired to construct sewers that will carry off the water from storms that occur every 5 yr., the figures supplied by the "5-Yr. Curve" are used; if the 10-yr. period is selected, that curve is used;

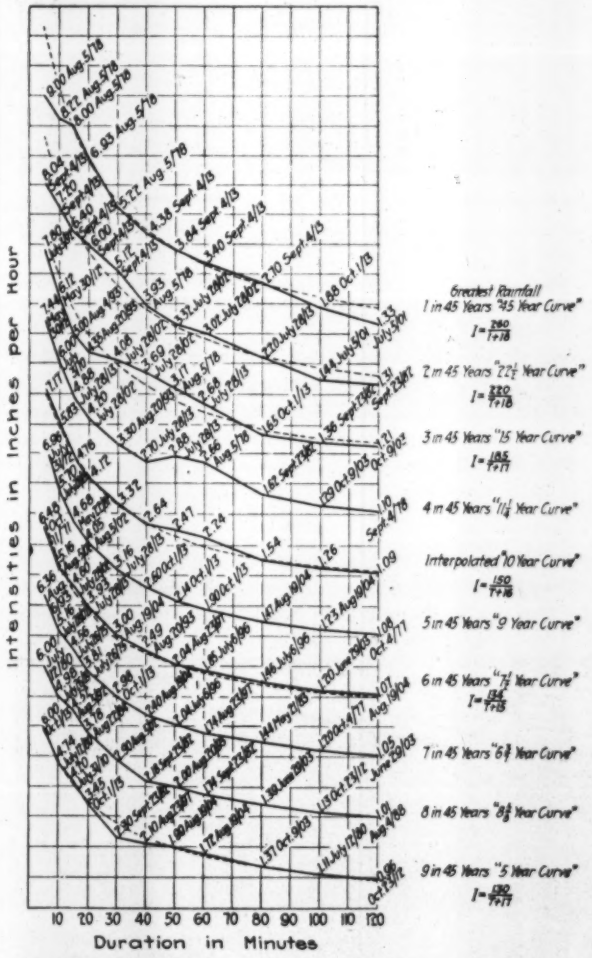

Intensities in Inches per Hour
Duration in Minutes
10 20 30 40 50 60 70 80 90 100 110 120
Greatest Rainfall
1 in 45 Years "45 Year Curve"
I = 280/t+18
2 in 45 Years "22½ Year Curve"
I = 220/t+18
3 in 45 Years "15 Year Curve"
I = 185/t+17
4 in 45 Years "11¼ Year Curve"
Interpolated "10 Year Curve"
I = 150/t+18
5 in 45 Years "9 Year Curve"
6 in 45 Years "7½ Year Curve"
I = 134/t+18
7 in 45 Years "6¾ Year Curve"
8 in 45 Years "8½ Year Curve"
9 in 45 Years "5 Year Curve"
I = 130/t+17

FIG. 2. NEW YORK RAINFALL CURVES BY "AVERAGE-RATE" METHOD FOR INTERVALS OF 5 TO 45 YR.

or if it is desired to provide for the heaviest storms recorded, the figures from the "45-Yr. Curve" are applied.

The reasoning on which these curves are based is that storms that have occurred but once in 45 yr. will probably not occur again in a shorter period; those that have occurred twice in 45 yr. may be expected to occur every 22½ yr.; those that have occurred three times will occur every 15 yr., and so on. It is an application of the average method to the frequency as well as to the rates.

I have carefully described this method of average rates based on accumulated rainfall for selected periods and given all the data on which its reasoning is based because I desire to point out some of its peculiarities. But before I do that I will give all the data in another form.

(To be continued)

Paving Methods in Manhattan Borough Revised

The following excerpts from the recently issued report of Eugene W. Stern, Chief Engineer of the Bureau of Highways, Borough of Manhattan, New York City, are of interest to paving engineers. Of the adequacy of 6-in. concrete foundation he writes:

The question is often raised as to the desirability of increasing this depth on account of heavy traffic and to provide sufficient strength in the base to span settlements, cave-ins and shrinkage in the subgrade. Investigation of the failures in concrete foundations in this city shows that unless there is reason to believe that the subgrade is a recent fill, 6 in. is adequate and is able to support the pavement under normal loads.

In regard to the treatment of creosoted wood paving blocks, Mr. Stern says:

To avoid bleeding, besides the ordinary treatment when being creosoted, the blocks have a final steaming and vacuum treatment, and the amount of oil has been reduced from 18 to 16 lb. per cu.ft.

He has experimented with night work to expedite pavement construction in congested thoroughfares, and writes:

One of the more important streets paved during the year was 32nd St. between 5th Ave. and Broadway. This is a very busy street, connecting Fifth Ave. with the Pennsylvania Station. The work was expedited as much as possible, night and day, the contract providing that the contractor should work 16 hr. a day, and it is believed that a record was made in its completion, which took 18 days from start to finish, during which time the street was closed to traffic for only eight days.

The result of handling the work in this manner proved so satisfactory in every way that it is proposed in the future to require night and day work on all streets in congested districts where there could be no objection to night work.

It seems that Mr. Stern has definitely abandoned the sand-cushion method of granite-block pavement construction, and has substituted asphalt for tar as a joint filler. He states that:

A 1-in. mortar bed, consisting of 1 part portland cement to 3 parts sand has been substituted for the sand bed, or so-called cushion. This has proved entirely satisfactory, and the resulting improvement in the pavement has fully justified the change.

For some time it has become apparent that the paving pitch for filling the joints, made of coal tar, was not giving satisfaction. At the end of even one year the joints would not remain filled. This was due to the fact that in warm weather the coal-tar filler would soften and leave the joints, and in cold weather it would chip out. When the joint does not remain filled, the paving blocks quickly wear round on the edges and soon a noisy rough pavement is the result.

To improve this condition, early in the year 1915 asphaltic joint filler was adopted, for the reason that it had greater tenacity, was less brittle in cold weather and not so soft in warm weather. The asphaltic filler has justified expectations; a comparison of those streets laid last year with asphaltic and coal-tar filler proves conclusively the superiority of the former.

A Rail-and-Road Electric Car has been built by C. J. Spencer, manager of the Bradford (England) Tramways. The vehicle consists of a modified standard motor-truck chassis, provided with a battery, enabling it to leave the tramway rails and operate as an ordinary self-contained vehicle when the occasion demands. In addition to being self-contained for special work, it is also equipped with electric street-car equipment, including a trolley. Contact with the rails is made by means of a cast-iron block connected to the steering gear and automatically steering the vehicle. The motors are of 20 hp., operating normally at 500 volts on the usual series-parallel system of control. When the vehicle leaves the tramway the rail contactor is lifted, the trolley pole pulled down, and a switch thrown to bring the batteries into action. Owing to the batteries having lower voltage than trolley wire, the speed free running is lower than when on rails, but the vehicle is able to climb any ordinary road gradients. The batteries can be charged while running on the tramway routes.

Earth Dam with Sheet-Steel Diaphragm and Cutoff

In enlarging a 67-ft. earth dam founded partly on the silt bed of the Sevier River in Juab County, Utah, a novel method was employed to prevent seepage under and through the dam. Parts of the dam, the two ends, where rock is found at moderate depth (see Fig. 1), are provided with reinforced-concrete core-walls, which in plan follow approximately the contour of the underlying ledge. The middle part of the dam rests on 30 to 40 ft. of silt overlying the ledge, and here steel sheetpiling was driven; to the top of the piling a sheet-steel diaphragm was fastened and carried above the water level of the reservoir. The ends of the steel piling and diaphragm were incased in the ends of the concrete core-walls, forming a water-tight curtain from bedrock to 6 ft. above the high-water line of the reservoir. Construction has been in progress since 1912 and is now about completed.

The original dam, having about a 1,000-ft. crest, was designed to store a 60-ft. head of water with 7-ft. freeboard. The new dam, with a 1,300-ft. crest, completely incloses the old one and stores 80 ft. of water with 13-ft. freeboard. The base of the old dam was widened from 300 to 700 ft., at the maximum cross-section, and the surface area of the reservoir was increased from 3,630 to 10,000 acres. The capacity of the reservoir has been increased from 104,000 to 250,000 acre-ft. In order to accommodate the increased base of the dam, the outlet tunnel was extended upstream 202 ft. as a reinforced-concrete conduit, and a gate tower with gates at elevations 0, 30, 40 and 50 ft. was added for better control of the outflow. A spillway is cut in solid rock at the north end of the dam, with gate-controlled outlets at 60- and 80-ft. elevations.

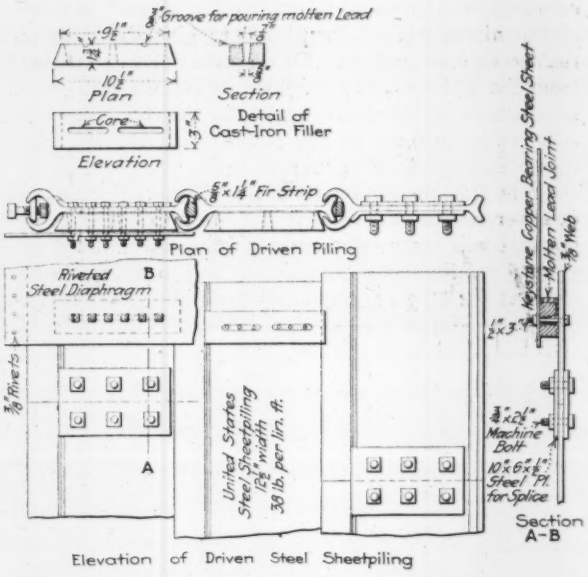


FIG. 2. DETAIL OF WATER-TIGHT CONNECTION OF STEEL PILING AND DIAPHRAGM

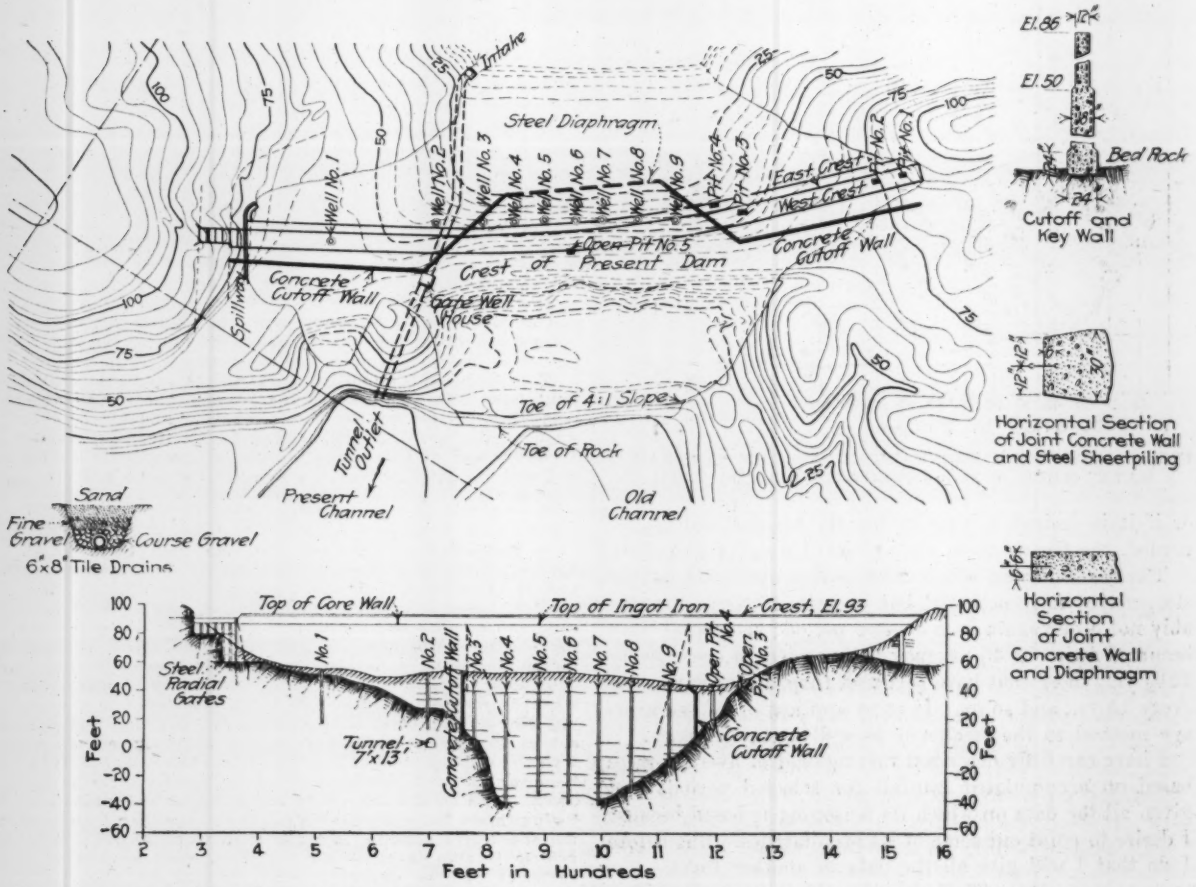


FIG. 1. PLAN AND LONGITUDINAL SECTION OF SEVIER BRIDGE DAM, JUAB COUNTY, UTAH

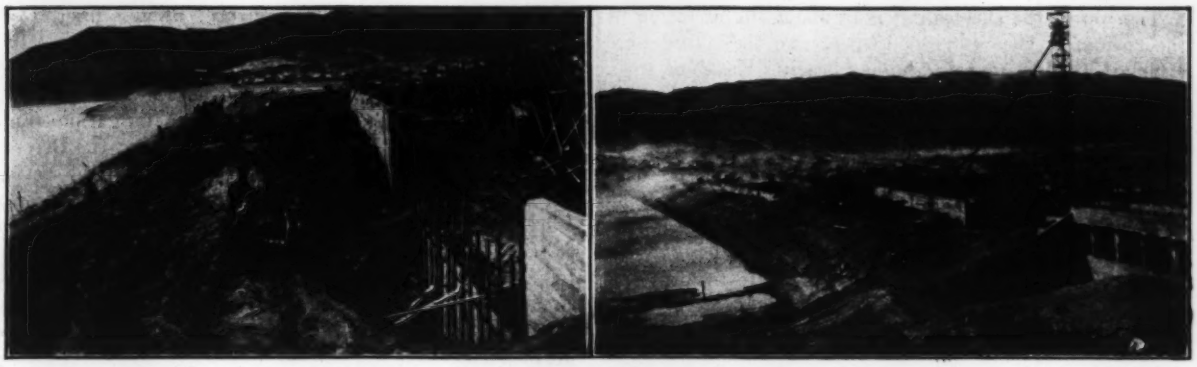


FIG. 3. CONSTRUCTION VIEWS OF SEVIER BRIDGE DAM, JUAB COUNTY, UTAH

The old dam contained about 200,000 cu.yd. of material. The additional material on the downstream side of the center line amounts to 140,000 cu.yd. and on the upstream side 340,000 cu.yd.—in all, the new dam contains about 680,000 cu.yd. of earth. The new fill was made with a mixture of clay and gravel, the gravel being

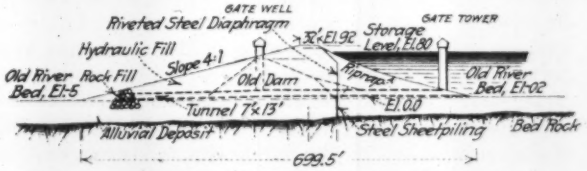


FIG. 4. CROSS-SECTION OF SEVIER BRIDGE DAM, SHOWING STEEL DIAPHRAGM

sluiced and carted from the north end of the dam and the clay carted from the opposite end. The carts were driven across the dam, loading alternately on opposite sides, which provided for about the right mixture of gravel and clay and at the same time assisted in compacting the material. The hydraulic fill is on the upstream side. A temporary hydraulic power plant furnished the power for the pumps that supplied the monitors for sluicing, electric power for lighting and the air compressors for furnishing air to the pneumatic riveters.

Previous to adding any new fill, the reinforced-concrete core-walls were extended as shown in Fig. 1, leaving a gap of about 240 ft. for the steel diaphragm. For the steel sheetpiling a trench was dug near the upstream toe of the old dam, as shown in the cross-section, Fig. 4. Approximately 11,000 lin.ft., or 200 tons, of 12½-in. 38-lb. United States steel sheetpiling was driven to bedrock in lengths of from 20 to 40 ft. The cost of driving, including plant and preliminary work, was about 35c. per lin.ft. The actual driving occupied about 30 days, two shifts, five to eight men in a shift. The total cost of the sheetpile cutoff, including the connections with the concrete wing core-walls, was about $21,000.

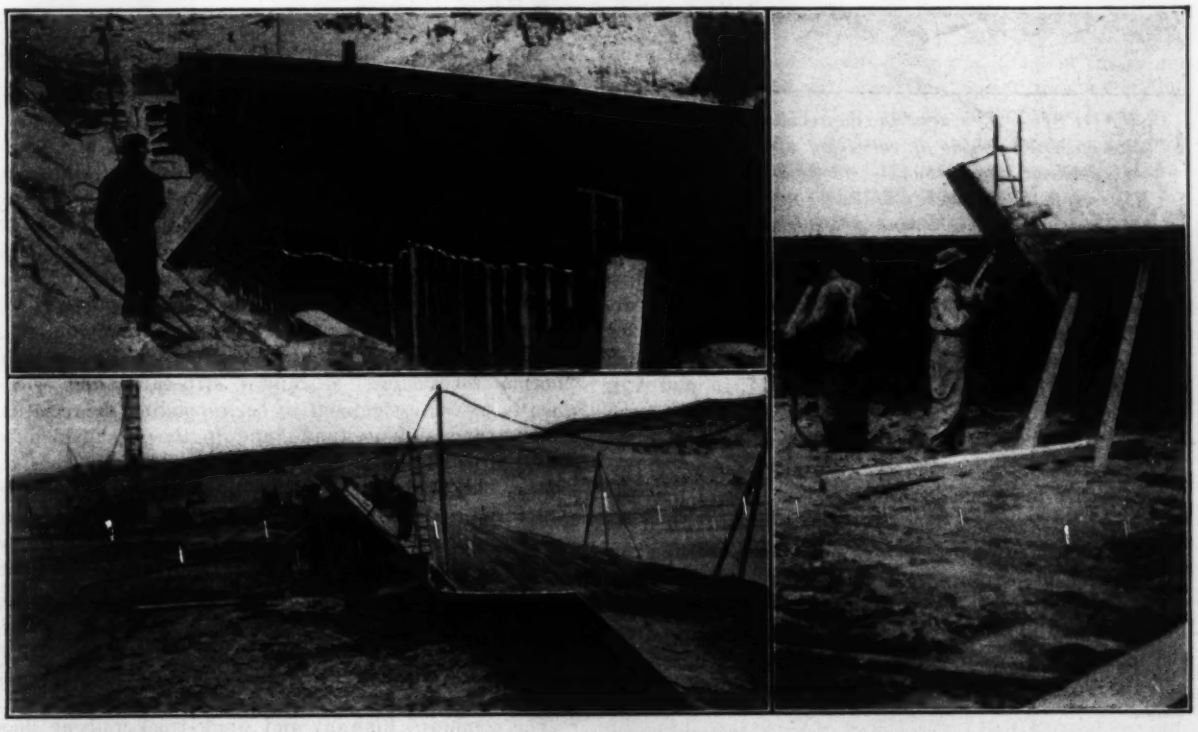


FIG. 5. ERECTION OF SHEET-STEEL DIAPHRAGM, SEVIER BRIDGE EARTH DAM, JUAB COUNTY, UTAH

The top of the sheetpiling is at about the elevation of the bottom of the reservoir (zero). To the piling were attached 4x10-ft. plates of copper-bearing Keystone steel, No. 10 gage, fabricated by the American Bridge Co. A detail of the water-tight connecting joint is shown in Fig. 4. The ends of the plates lapped over on the upstream face and were riveted with ⅜-in. rivets, with 1½-in. spacing. Every five plates, or at intervals of 50 ft., expansion joints made of U-shaped pieces of the same steel were placed (see Fig. 5).

The diaphragm was carried up vertically to an elevation of 61 ft., then bent in on a 1:1 slope to an elevation of 86 ft. (see cross-section, Fig. 4). About 30,000 sq.ft. of metal was used in the diaphragm. Besides the shop coat of red lead, the metal was given two coats of asphaltic paint, applied hot. Experience with steel drills left in holes in the outlet tunnel, constructed in 1905, leads to the belief that little deterioration will occur, for the river water is strongly impregnated with lime, which is precipitated and forms a protective coating on exposed iron and steel. The cost of the steel delivered at the dam was about $6,500 and the cost of erection about $4,500, making a total of $11,000.

The core-walls, which contain approximately 3,000 cu.yd. of concrete, cost complete, including excavation, about $30,000. The total cost of the water-tight curtain, steel sheetpiling, diaphragm and core-walls was about $62,000, or 8% of the total cost of enlarging the old dam, including land damages. Experiments show that the seepage through the fill has been practically stopped, but there exist some small springs on the downstream side whose flow is probably through fissures in the underlying rock.

The dam is known as the Sevier Bridge dam because its crest carries a highway. It is part of the reservoir and water-supply system of four large irrigation companies, namely, the Delta Land and Water Co. the Deseret Irrigation Co., the Melville Irrigation Co. and the Sevier River Land and Water Co. whose several projects cover more than 100,000 acres of land in eastern Millard County, Utah. The last named company, with offices in Salt Lake City, has administered the business detail of the enlargement of the dam and reservoir. J. R. Harsch is secretary of the Sevier River Co. The following engineers have been connected with the work: Charles Hardy, chief engineer, 1905 and 1906; R. R. Lyman, chief engineer, 1907 to 1913, and consulting engineer to date; D. G. Martin, resident engineer, 1914; C. A. Tush, consulting engineer, 1913 to 1916; and Clarence S. Jarvis, chief engineer, 1914 to date. The late James D. Schuyler made a study and a report on the enlargement of the dam and insisted on the necessity of a cutoff wall to at least 30 ft. above the bed of the river. Mr. Jarvis first suggested the steel diaphragm in 1914, originally intending it to be of corrugated ingot iron, but owing to the experience with Sevier River water already referred to, he changed to copper-bearing steel. Associated with Mr. Jarvis during 1915 and 1916 has been L. H. Kimball in direct charge of the construction of the diaphragm. A precedent for the metal diaphragm is the Avalon dam on the Pecos River, New Mexico.

Condition of Iron in the Old Keokuk Bridge

By George C. Hinckley*

SYNOPSIS—A study in depreciation and obsolescence. Analysis of condition of the 45-year-old cast-iron and wrought-iron bridge across the Mississippi at Keokuk. Metal shows up remarkably well after many years of service.

During the past year, the old iron toll-bridge which spanned the Mississippi River at Keokuk, Iowa, for nearly half a century, has been dismantled and replaced by a modern double-decked structure, descriptions of which appeared in *Engineering News* of Aug. 5, 1915, and Apr. 13, 1916.

The old structure carried a narrow, combined highway and single-track railway floor. The decision to replace it was partly responsive to the popular demand that the highway and railway floors be separated, in order to relieve the congestion and provide a safe crossing for the rapidly increasing automobile traffic. It was due primarily, however, to the fact that the old bridge was too light to sustain with safety the increased loading from the modern rolling stock of its tenants, the Wabash Ry. and the Toledo, Peoria & Western Ry.

*Constructing Engineer, Keokuk, Iowa; Resident Engineer of the Keokuk and Hamilton Bridge.

In these respects the old structure presents an interesting and typical example of obsolescence, due to inadequacy in the face of an increasing volume of traffic, and to its inability safely to sustain modern loads. But it is the purpose here to record the conditions of actual wear and deterioration due to nearly 50 years of use and exposure, and the degree to which the strength and stability of the structure have been effected thereby. Reliable information of this kind is of value aside from its purely engineering value, in view of the widely divergent opinions and practices now existing with respect to the assumed "normal service life" of railway structures, and consequently to the assignment of corresponding depreciation reserves and sinking funds, and to the establishing of valuation rules and precedents.

The old bridge was a wrought-iron and cast-iron structure, designed by J. H. Linville for a live-load approximating Cooper's E-20, and built by the Keystone Bridge Co. in 1869 and 1870. It consisted of a 380-ft. drawspan, two 256-ft. and eight 165-ft. fixed spans. All of these were skewed through-truss spans of a modified Whipple type, otherwise known as the Linville-Pratt truss, with vertical end-posts, and double-intersection web systems, giving panel lengths of 12 to 15 ft.

The combined highway and single-track railway floor was supported upon Douglas-fir stringers resting at the

panel points upon iron floor-beams. These were built up from two wrought channels with cast-iron separators, and stiffened by means of queen-post trusses consisting of wrought eye-bars and cast posts. The floor-beams were hung from the lower chord pins by two short wrought loop-rod hangers at each end. These passed down between the channels through cast yokes beneath, the connections being held more or less rigidly by means of cast saddles, fitting between the floor-beams and the lower chord pins, so that when the nuts on the lower ends of the hanger rods were tightened, the beams were clamped tightly to the pins. No floor-beams were provided between the end-posts over the piers, these posts being spaced laterally at their bottoms by cast struts and long bolt-rods.

The bottom lateral system consisted simply of adjustable wrought loop-rods fastened to the sides of the

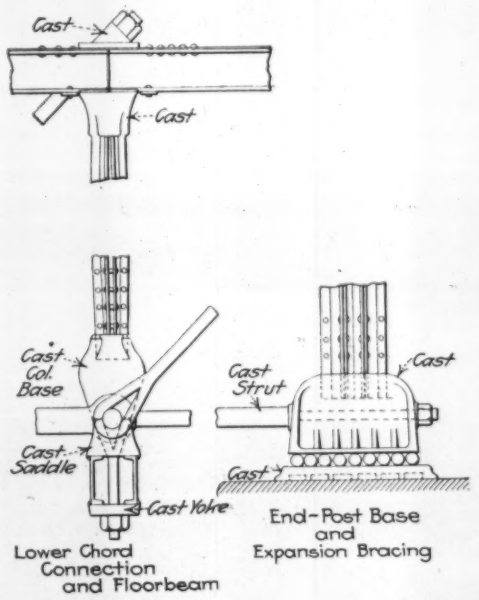


FIG. 1. DETAILS OF TRUSSES OF THE OLD KEOKUK BRIDGE

floor-beams. The lower chords, except on the drawspan, were composed of wrought eye-bars, the end panels being formed by loop-rods bolting through the cast bases of the end-posts and stiffened by cast struts. The truss diagonals were all square wrought loop-rods extending from the lower chord pins diagonally up through the top chord just over the posts where they were fastened by means of large nuts screwed down against cast-iron chairs resting on top of the upper chord.

The intermediate posts were built up of four rolled shapes fastened together edgewise by rivets and spacers to form open hollow Phœnix-like columns, tapering from the center toward the ends, around which were molded the cast-iron tops and bottoms. This is shown in Fig. 1. The cast tops abutted on the top chord without any fastening whatever. The bottom castings were webbed and chambered to engage the upper half of the lower chord pins and act as spacers for the eye-bars. All the posts were set in loosely between the chords and were clamped to secure positions by the tightening of the nuts on top of the diagonals and by the action of the truss under load.

The upper chords were composed of sections of one-panel length, made up of two channels and two I-beams each, to which was riveted a single top cover-plate. These sections abutted over the intermediate posts but were not spliced, being held in position by the diagonals and the action of the loaded bridge. The vertical end-posts were built-up hollow wrought columns around which were molded cast-iron tops and bases. The upper chords simply rested upon the end-posts, being held down by the diagonals which passed up through the cast tops. The end-post bases rested either directly upon pier pedestal castings or upon expansion bearings consisting of nests of 2-in. rollers for the short spans and 3-in. rollers for the two long spans. Portals were all made up of cast-iron sections bolted together and to the posts. The top lateral system consisted of cast struts at the panel points and wrought adjustable loop-rod diagonals.

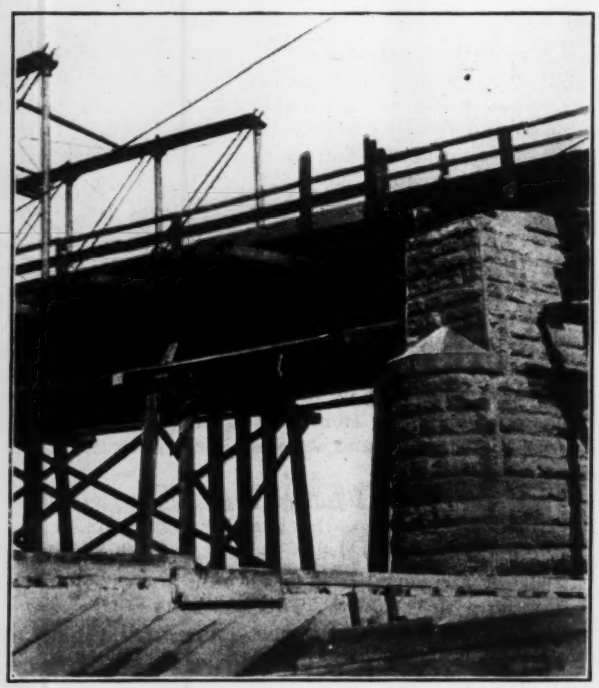
The drawspan was of similar design except that the upper chord sections were spliced to form a continuous bow-shaped member. The lower chords were stiff, being built up and spliced similar to the upper chords. There being no pins in the bottom chord, the diagonal rods and counters extended down through the chords to cast chairs, being held by nuts, precisely as at the upper chord points, while the intermediate posts were held in place between the chords, both at the top and bottom, by the tension in the diagonals. The drawspan trusses were provided with full systems of adjustable counters. The intermediate floor-beams on the draw were similar to those of the fixed spans and were similarly suspended from the lower chord by hanger bolts. The end floor-beams were built up from two channels with top and bottom cover plates, and were similarly hung from the lower chords.

The drawspan was a full center-bearing structure for all loads and positions, the live-ring rollers under the drum simply acting to steady the motion. The load was carried on a wrought-iron drum built up as a curved box girder with two webs. This was hung on the center bearing by means of adjustable radial rods extending inward and upward from the bottom of the drum to a large forged spider resting on an ingeniously designed double cone-roller bearing in the center casting. It was operated by a small reversible steam engine of approximately 12 hp., operating through the usual gear reductions to two opposite pinions on the drum engaging a cast-iron rack which was bolted with the lower roller-tread castings to the pier. The ends of the drawspan were raised by means of a centrally operated pair of hydraulic jacks and were wedged by a hand-operated mechanism. The engine and operating machinery were built about 1865 by William Sellers, of Philadelphia, Penn.

The substructure consisted of the abutments at either end of the bridge and 11 river piers, including the pivot pier of the draw-span. Of these, all but five of the smaller ones were built directly upon the rock bottom of the river, which at low water nowhere exceeds 8 or 10 ft. in depth. The remaining five piers were founded upon shallow timber grillages resting on the rock bottom. The pier masonry was quarry-faced ashlar, except that the upstream nose-stones, starlings and copings were hammer-dressed, and were laid up in mortar probably made from Utica (Ill.) natural cement,

and backed with large stones laid at random in spalls and mortar. All the stone was a local magnesium limestone. The pivot pier was a hollow structure with a solid center pier connected by four radial walls to an outer masonry ring.

During its 46 years of service the old superstructure was repainted five times, always with either red or white lead and oil. The original pine floor stringers were replaced with another set of pine timbers after ten years' service, and these were again replaced ten years later by Douglas fir stringers. These remained in service for the remarkable period of 22 years and were then found to be perfectly sound, except for dry-rot at their ends. In 1889, a new center casting was installed at the draw to replace the original one, which had been cracked by



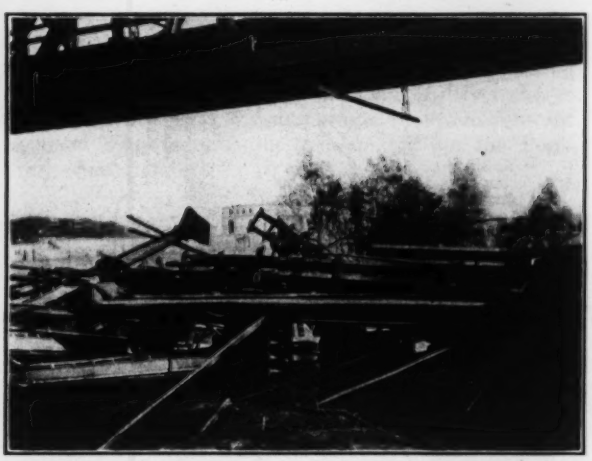


FIG. 2. DISMANTLING THE OLD KEOKUK BRIDGE ACROSS THE MISSISSIPPI

The view at the left shows the trusses partly dismantled, and the temporary track stringers and deck supported on falsework. The view at the right shows a pile of old truss posts, etc., beneath one of the new spans

unequal settling due to the disintegration of the center coping stones.

Aside from the above, there has been practically no further outlay required for superstructure maintenance, except for the occasional replacing of a cracked yoke casting on the floor-beam hangers and for small current repairs to the operating machinery. On four or five of the piers, including the center of the pivot pier, the copings and top courses had become so cracked and loosened that it became necessary several years ago to reinforce their tops by means of cast-iron jackets set in grout and clamped on by long bolts. The piers have been repointed once and some patching has been necessary from time to time in order to repair stones broken by floating ice.

Observations covering a long period prior to the dismantling of the bridge disclosed the fact that several of the expansion bearings were not acting, but instead, that the vertical end-posts of the trusses were acting as rockers, fixed at their bottoms and carrying the spans on their tops. Temperature stresses in the bottom chords had resulted in many cracked end-post bases, having caused the end chord members to be pushed entirely through these castings in several cases. It is fortunate that in this type of truss the end sections of the bottom chord are not required to carry live-load stresses, as otherwise the conditions described above must have been attended with very serious consequences.

Upon dismantling the expansion bearings, they were found to be badly rusted without exception, and in some cases the rollers were incased in solid masses of rust and showed no evidence of having moved for several years. While this condition, which was the worst encountered so far as rust was concerned, can be attributed in a measure to the fact that the roller nests were too compact and inaccessible for proper cleaning and air circulation, it was caused principally by water accumulating in the bottoms of the hollow end-posts and base castings, which in freezing probably cracked the bases and gradually seeped down onto the rollers, keeping them continually wet.

Excepting the roller bearings, the structure was found to be remarkably free from rust. The only instances noted that are worthy of mention were at some of the contacts between the upper chord and the top castings of intermediate posts, where the chord flanges had been reduced about $\frac{1}{16}$ in., corresponding to less than 5% of the chord section area. Also a few instances where rust had expanded under the edges of the chord cover plates, causing them to buckle between rivets which were too widely spaced, but not seriously reducing the sectional area. The threads on pins and hanger and diagonal rods were found in perfect condition, no difficulty whatever being experienced in removing the nuts. There were no signs of serious deterioration where the exhaust gases of locomotives had come in contact with the portals and top laterals, a condition largely due to the fact that these members were mostly of cast iron.

On the whole, the lower chord pin connections were found to be in uniformly excellent condition both as to wear and rusting. The pins themselves were practically free from rust pitting and no instance was noted where

the wear from the chord bars or diagonals had exceeded $\frac{1}{32}$ in., corresponding to about 2% of the pin-section area. The pin holes in some of the chord bars showed a little pitting, but no evidence of wear worth mentioning. The pin holes of the diagonal loop-rods, on account of their elongated shape, allowed of motion on the pins parallel to the axes of the diagonals. Such a movement must have occurred in several cases, as many of these pin holes were found to be worn down as much as $\frac{1}{8}$ in. on their upper sides, where they lay on the pins, thereby resulting in area reductions up to about 5% of the effective section of the diagonal.

This wear was obviously the result of the sliding of the pins down into the bottoms of the eyelets upon application of the live-load, a fault due to loop-rod members which have not been kept in good adjustment. The pin bearing surfaces on the cast bases of the intermediate posts were not noticeably worn, nor was any evidence of serious wear noted in the eyelets of the floor-beam hangers.

Considering the large percentage of cast iron in the old structure, there were surprisingly few cracked castings encountered, aside from those mentioned in connection with the expansion bearings. At the ends of the draw-span the pedestal castings on the piers were found so badly cracked as to be worthless, a condition no doubt due to impact with the closing drawspan, which had settled below its end clearance. Other instances of cracked castings were confined to an occasional top chord chair casting and a few floor-beam hanger yokes.

No Crystallization Found

In view of its long term of service and the heavy overloading which the old bridge had been sustaining in recent years, it was expected that evidence of crystallization would be found, especially in the diagonal tie-rods and floor-beam hanger rods. It is reliably reported, however, that during the past 35 years no failures whatever have occurred which could be attributed to crystallization, with the possible exception of three or four broken counters and one main diagonal which had snapped off under the nut while it was being adjusted. The counters were said to have been adjusted too tightly, a condition frequently encountered on railway bridges whose adjustments have been left to bridge foremen unfamiliar with the elements of truss action.

The absence of crystallization was further demonstrated during the process of wrecking the structure, when the diagonal rods were burned off near their tops and were allowed to fall or swing down onto the lower chords and floor-beams in such a manner that nearly all the rods were bent and some were bent almost double. Moreover, all of the wreckage was piled indiscriminately, and in so doing a number of the chord bars and other wrought members were badly bent and twisted. Notwithstanding this severe bending not an instance was noted wherein a rod or other wrought member had been broken or cracked. Considering this behavior under treatment vastly more severe than the standard drop and bending tests, it must be admitted that crystallization, if present at all in the structure, had not reached a stage approaching the dangerous.

Practically all of the original operating machinery was still in use on the bridge when it was dismantled. The old boiler had passed state inspection for the current year and was in fair condition. The engine showed considerable racking and lost motion, as did the gear train, where the teeth had been worn off an average of about one-third their thickness. The friction clutches, hydraulic jacks and other machinery were in fair workable condition. On the whole, it may be fairly said of the machinery, that it had reached that stage of depreciation when its future efficiency could not have been relied upon without constant and relatively expensive repairs.

Condition of Masonry

As the rebuilding of the bridge involved the removal of the top five or six courses of masonry from all the old piers, in order that new concrete copings could be substituted, the condition of the upper parts of the piers could be ascertained with accuracy. Below the new copings the piers were given a careful surface examination, the cracks and open joints being probed as well as possible, and the grillages and foundations being examined with the aid of a diver's outfit. On practically all of the piers the coping stones under the bridge seats were found to be cracked, while in some cases they were badly shattered and loose on their beds. That this condition must have existed several years ago on four or five of the piers, is evidenced by the cast-iron jackets, already mentioned, which were placed at that time.

This same condition was found generally true for the first few courses below the old copings, where the face stones were found to be loose and the backing more or less disintegrated, but except in one or two instances, this condition did not seem to extend below the starling coping courses. Several of the piers showed small, closed vertical cracks extending down from the bridge seats, sometimes to below the water line, but only in the case of one pier were they considered of enough moment to warrant rebuilding below the starling.

Between the high and low water lines at several of the channel piers, the nose stones showed the effects of ice erosion, some cases being noted where parts of stones were missing and their openings sometimes patched with concrete. This damage was not found to be extensive, except on one of the long span piers, where the entire nose had been wrecked and several of the stones carried away. Below the water line both the masonry and timber grillages were observed to be in uniformly good condition.

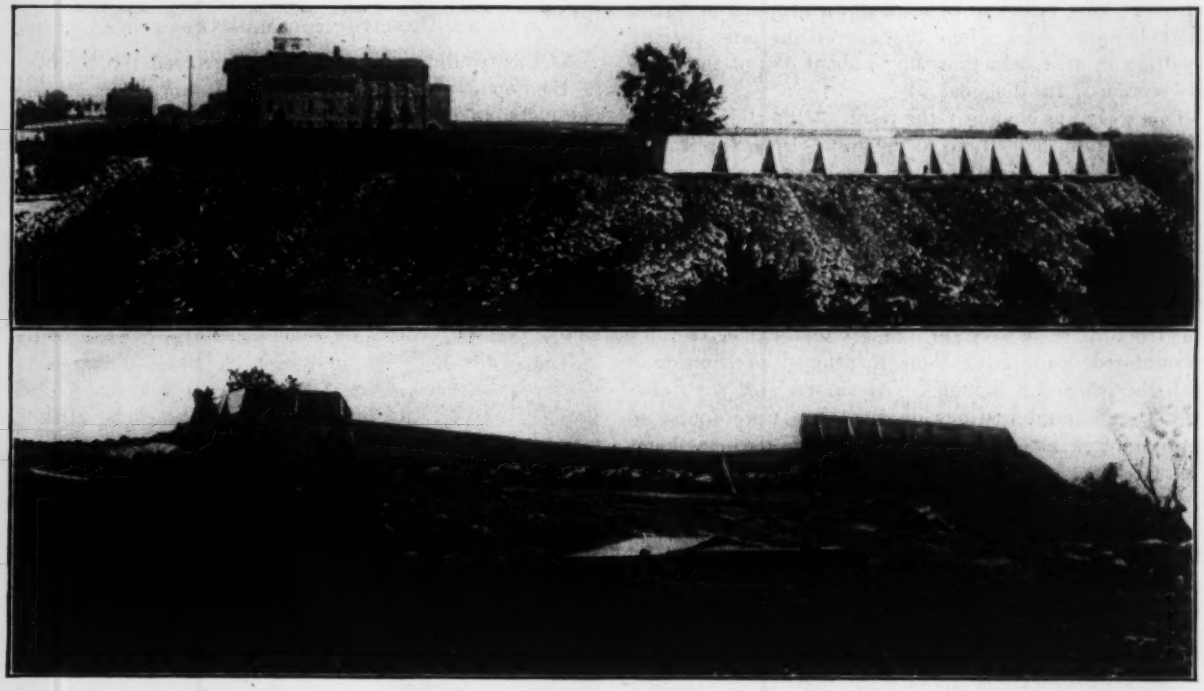
Considering the above details of deterioration with a view to their effect upon the ability of the structure safely to continue performing the functions and sustaining the loads for which it was originally conceived and designed, the one manifestly important conclusion to be drawn is that it had not nearly approached a state of general depreciation serious enough to impair its usefulness. With an expenditure estimated at less than 5% of the structure's value, to cover pier repairs, new expansion bearings, and partial renewal of operating machinery, there was no reason deducible from the foregoing data, why an additional 20 or 30 years of service could not conservatively have been expected of the structure. This would be attended, perhaps, by slightly increasing annual outlays for maintenance, and provided of course, that the weight and volume of the traffic should remain within the limits imposed by the original design.

The Strobel Steel Construction Co., of Chicago, had the contract for the removal of the old bridge and the construction of the new bridge. The latter structure was designed by Ralph Modjeski, Consulting Engineer.

Failure of Concrete Reservoir Built on Old Stone Wall

A concrete reservoir wall at Winfield, Kan., failed on June 6 under about the full head of the reservoir. The escaping water caused quite a flood in the neighborhood of the near-by St. Johns College, but little material damage was done to anything but the structure itself. The wall was of crude design, and its failure is interesting because of that fact and because, too, the city officials had been warned of the insufficiency of the design.

About 40 years ago an emergency reservoir was built on a slight height of land in Winfield, by inclosing a rectangular area in a masonry wall and filling outside to a normal slope. This basin was about 10 ft. deep and had the natural rock bottom. In 1914 the need for additional storage led the city to design a new wall, increasing the depth of the reservoir 6 ft. This consisted of a thin concrete lining reaching from the bottom of the basin, which was floored with plain concrete, to the top of the old wall, and with slightly increased thickness extending up the required 6 ft. as a buttressed concrete wall. The buttresses, as shown in the views, rested on an outside platform of concrete poured on top of the stone wall. The new reservoir was to have a capacity of about 4,000,000 gal.



FIGS. 1 AND 2. ENLARGED RESERVOIR AT WINFIELD, KAN., BEFORE AND AFTER FAILURE

The concrete in the new section was not reinforced in the original design. In an effort to persuade the city to build a more secure addition, a reinforcing-steel company submitted to the city the plans for a similar design, in

FIG. 3. NEAR VIEW OF BREAK IN WINFIELD RESERVOIR

which the floor was reinforced and the walls and lining were carried up as a reinforced-concrete slab tied into the floor, but depending for stability on the restraint given by the stone wall against which this slab backed. This design was made by a consulting engineer at the instance of the steel company and on the representation that the old wall was very carefully built of dimension stone and laid up in cement mortar—in short, that it was a very good specimen of stone masonry.

The steel company submitted its design together with a bid for $1,500 for the reinforcement, but it was rejected by the city on account of the extra cost and because of the opinion that the original design was fully strong enough. As a concession to the views expressed, however, a concrete floor was added (but it was not reinforced), and horizontal reinforcement was placed, extending about 3 ft. each side of the corners in the vertical walls. The construction was carried out on this plan, the resulting reservoir appearing as shown in Fig. 1.

The failure of June 6 washed out practically all of one side of the wall (Fig. 2), carrying the sections of concrete and old stone wall down the slope and washing out practically all the old earth slope opposite the break. It is thought that the first break occurred between the new concrete floor and the new concrete lining and that the water thus released easily passed through the stone wall, which was anything but good masonry. Fig. 3 shows very well the section and condition of the old masonry and the general form of the concrete addition. At places there appears to be evidence of reinforcement, but the sections of rods are very light and the distribution most general.

New York Zoning Regulations*

The city government of New York has just put into effect by a virtually unanimous vote of the Board of Estimate and Apportionment the radical and much talked of zoning restrictions. All future buildings will be restricted as to their height, size and use, and the restrictions will be different in different parts of the 327 sq.mi. of the city.

In general, the law will limit the height of buildings in proportion to the widths of the streets on which they face, all the way from 2½ times the width of the street in the financial district, through two times the width of the street in central Manhattan, with 1½ times in the remainder of Manhattan and in small portions of the other boroughs, down to once the width of the street throughout all the rest of the city. A future Equitable Building could only be a third as high, because it faces on narrow streets; but a tower in the center of it, half as large again as the Woolworth tower, might rise to any height. The Woolworth Building, on the other hand, if facing on a park, might be very nearly duplicated. The shopping district on Fifth Ave. will consist of buildings not much higher than Tiffany's, but along 42nd St. buildings may rise about as high as the Hotel Manhattan or the Knickerbocker. Twelve- and 14-story apartments will continue to go up on the main avenues and eight and nine-story apartments on the side streets, but no building of any kind can go any higher except by being set back from the street. Throughout most of the city, however, four or five stories will be the limit. Towers may be built to any height, but they can not cover more than a quarter of the lot. Mansards, dormers and terraces are encouraged—anything that will open up the streets and bring light down into them by setting the upper part of the buildings back from the street above a reasonable height.

The size of buildings will be controlled by the fact that the law requires just so much open space on each lot. This again ranges all the way from the warehouse districts along the commercial waterfront and along the freight railways, where a building may cover the whole of its lot, through the B, C and D districts so called, in each of which in succession a building has to provide for larger and larger yards and courts, down to the villa districts where a house can cover only 30% of its lot and must be widely separated from its neighbor on at least one side. Throughout Manhattan and the densely built-up portions of the other boroughs, yards and courts in office buildings, factories, lofts, hotels, apartments, in fact all buildings, would have to be as large as those that have been required for the last 14 years in tenement and apartment houses. Everywhere the yards and courts have to be increasingly larger at the top as a building goes up in height, so much so that these requirements tend to limit the practicable economic height of buildings even more effectively than do those directly affecting height. This is particularly true in the outlying boroughs. One important feature of the law is the encouragement it gives to playgrounds, for material concessions are allowed to anyone who will provide adequate recreational space in connection with his buildings.

Right here it is desirable to sound a note of warning. It would be most unfortunate if the law were applied as it stands to other cities, for it is full of unduly liberal provisions in the way of height and size that tend strongly to defeat the object of the law, but which were necessitated by the exceptional economic conditions of New York.

As to the use of buildings there are only two general classes of restrictions: (1) The districts which are restricted against business and industry of all sorts, the so-called "residence" districts, and (2) the tracts which are restricted only against manufacturing and public stables and garages, the so-called "business" districts. In the former almost any kind of building that people live in is allowed, also churches, schools, hospitals and various institutional buildings. In the business districts any residence use is allowed and even a certain small proportion of the unobjectionable types of manufacturing. The use districts have been laid down street by street and in fact block by block, depending on existing conditions and tendencies. The result has been that about two-fifths of Manhattan and about two-thirds of the whole city have been set aside for all time for strictly residential use, while the main thoroughfares, the transit streets and all other streets that are or might be appropriately used for stores or showrooms are set aside as business streets. Many streets which are now seriously invaded by factories or garages are restricted against them from now on, because it was felt that they were a distinct harm to the street. On this ground all of the central part of Manhattan above 23rd St. was made a business district despite the fact that there were already hundreds of factories employing in all upward of 30,000 operatives within the district. This law will not touch the existing factory lofts, as it is in no sense retroactive; but the

*From a statement by George B. Ford, Consultant to the Commission on Building Districts and Restrictions, New York City.

"Saving New York" movement, in which most of the merchants along Fifth Ave. combined to oust the factories in the neighborhood, has already succeeded in persuading almost all the manufacturers to move away. It was a remarkable and timely vindication of the economic need of this law.

All the rest of the city which is not in one or the other of these two kinds of districts is left unrestricted. It includes all the land appropriate for industry along the navigable waterfront and along the freight railways, as well as most of the territory which is now given over to manufacturing. It includes also scattered throughout the city a number of blocks which are already invaded by public garages or which are appropriate for that use. Certain other areas, especially around Jamaica Bay and along the shores of Staten Island, are left entirely undetermined in their use pending the working out of the plans for the port and terminal facilities of New York.

The law will be administered by the city superintendents of buildings in each of the five boroughs; and in so far as it affects tenement houses the law will be administered by the tenement-house commissioner, while the following up of buildings after they are completed will be under the jurisdiction of the fire commissioner. In any case, wherever there is any question about the application of the law in a specific case, the matter can be taken to the newly constituted Board of Appeals, which is the board of review for all matters that relate to the construction or use of buildings. In addition, the law has in it a number of specific clauses giving the Board of Appeals discretion in allowing exceptions to the law.

The law itself can be changed only by the Board of Estimate and Apportionment, which created it, and this body can, after due notice and hearing, make amendments at any time; but if in any case 20% of the property owners affected by a change object, the Board of Estimate can make the change only by a unanimous vote. There is also a clause which says that if on any street or district 50% of the property owners sign a petition for a change in the map as affecting that district, then the Board of Estimate must act on it in one way or another within 30 days.

Continuous Package Elevators on Philadelphia Piers

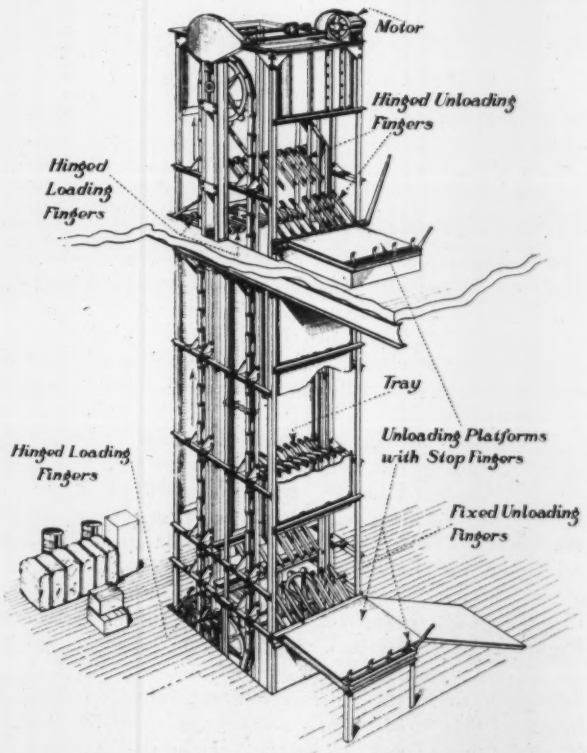
By Henry J. Edsall*

In order to facilitate to the greatest possible degree the handling of freight on the new Southwark piers in Philadelphia, it was the aim of the designers to provide the most modern types of equipment. The piers are therefore liberally provided with platform elevators, continuously operating package elevators, chutes, electric winches and automatic electric freight trucks. These piers, described in *Engineering News*, Aug. 26, 1915, p. 421, are at the foot of Queen and Christian St. and front on Delaware Ave., which is a very wide street along this part of the Deleware River waterfront. Each pier is 550 ft. long by 180 ft. wide, and the docks, on each side, are 200 ft. in width. At the inshore ends there are bulkhead sheds 30 ft. wide, extending along Delaware Ave., thereby increasing the cargo storage space and providing additional platform room for loading and unloading trucks. The substructures of the piers are of a permanent construction with massive concrete walls supported by groups of piles. The shed of each pier, of fireproof steel and concrete construction, is built with an upper deck 26 ft. 6 in. above the main deck.

The continuously operating package elevators are of more than usual interest, since they are of the latest improved design and are probably the largest installation of this kind in existence. These machines, of which there are four on each of the two piers, are arranged to handle bales, barrels and boxes and are automatic in their operation, it being necessary only to load the package onto the loading fingers, after which one of the trays picks it up and discharges it at either the upper or lower deck as desired.

Essential Elements of Elevators

These elevators consist, essentially, of two strands of heavy steel strap chain, with steel trays attached to the chains at intervals, by means of hangers at the ends, these hangers being hung on pins extending out from the chains. The chains travel around sprocket wheels at head and foot, but the hangers of the trays always hang vertically and the tray bottoms always remain horizontal. These trays are made with I-beams extending across centrally between the hangers and with fingers made of flat irons on edge attached to the beams at intervals and extending across them at right angles. This construction forms a tray bottom with slots between the fingers so that, at the loading and unloading points, other fingers can extend into these slots and either hold the package until it is picked up by a tray at the loading point or remove it from a tray at the unloading point.



PERSPECTIVE VIEW OF CONTINUOUS OPERATING PACKAGE ELEVATORS, SOUTHWARK PIERS

*Engineer, Link-Belt Co., Nicetown, Philadelphia, Penn.

While machines of this type operate at slow speed and require little power, because of the slow speed, and also because the up-and-down sides balance each other, except for any excess of load on one side or the other, still their handling capacity is great since the trays move constantly in one direction and come along at close intervals. In this case, the speed is only 30 ft. per min. and the trays are spaced a little over 14 ft. apart so that they come along at the rate of about 2 per min., or 120 per hr. There are four of these machines on each pier so that the combined capacity is over 480 packages per hour. The detail construction of these machines is as follows:

Framing of Machines

The framework of each machine is built of steel shapes, the corner members being 6x6x½-in. angles. Instead of the headshaft running through from one side to the other there are two studshafts. These studshafts are supported in heavy bearings, or brackets, attached between two vertical 10-in. channels, these channels framing into one of the girders of the upper deck on one side and into one of the deck I-beams on the other side. The footshaft runs through, and each takeup bearing for this shaft is bolted to a ¼-in. plate attached to two 3x2x¼-in. angles that, in turn, are attached to the main frame. At intervals there are 3x3x¼-in. angles forming girts around the frame. These girts are riveted to the corner angles. In between the ascending and descending trays there are double 2½x2½x¼-in. tie angles and at the loading and unloading points heavier ties of double 8-in. channels and, in one case, an 8-in. I-beam, these ties also forming supports for the inside loading and unloading fingers.

For the ascending and descending chains there are double 4x3x$\frac{5}{16}$-in. angles to form guides. These angles are attached to the girt angles. There are also two 3x3x¼-in. vertical angles on each side that are riveted to the girt angles and to the crossties. At the front and back of both the ascending and descending trays there are ⅛-in. guide plates extending all the way across so that the packages going up or down are confined between these plates which are riveted to 2x2x¼-in. vertical angles that, in turn, are attached by means of clip angles to the girt angles for the outside plates and to crossties for the inside plates.

The girt angles around the top of the frame are 5x6x⅜-in. angles. These support the bearings for two countershafts and also the motor, which is bolted to a plate that is riveted to the angles. There is an unloading platform 15 in. above the upper deck and one 3 ft. 6 in. above the lower deck. These are built of angles and channels with steel-plate bottoms. At the outer end there are hinged stop fingers keyed to a shaft and arranged to be raised or lowered by means of a lever. These stops are designed to keep the packages from going over the edge of the table when they are discharged onto it.

Details of Tray Construction

The trays are built as follows: The hangers are built of 5-in. channels and have a drop of 3 ft. 8 in. from the center of the pin to the top of the cross I-beam. From out to out of hangers it is 5 ft. 8 in., which leaves about 5 ft. 4 in. clearance between the hangers for the packages. At the top of each hanger there is a casting through which the 1⅜-in. pins extend. This casting is also designed to travel between the vertical guides. At the bottom of each hanger there is another casting that travels between the guides and prevents the trays from swinging when they are ascending or descending. The I-beam across between the hangers is a 6-in. beam and the fingers across the top of this I-beam are made of 2x¾-in. flats. These flats are bent down in the center so that a barrel will rest in the center of the trays and not roll out sideways. The clearance between the flats is 6¼ in.

The chains that carry the trays are built of 2x⅜-in. flats and are 12-in. pitch c. to c. of joints. These chains have ⅞-in. pins, 3¼-in. diameter rollers and case-hardened steel bushings at the joints.

The loading and unloading fingers that extend into the slots of the trays are built of steel angles, the ones at the unloading point on the lower deck being fixed in position and the others being hinged so that they can be thrown back out of the way. When sending packages from the lower deck to the upper deck, the lower-deck loading fingers and upper-deck unloading fingers would be in position, and the upper-deck loading fingers would be thrown back out of the way so that packages could pass this point, as it is necessary for the packages to travel up and over the head so that the unloading fingers can remove them from the trays as they are descending. When sending packages from the upper deck to the lower deck, the reverse is the case—that is, the upper-deck loading fingers would be thrown into position and the upper-deck unloading fingers would have to be thrown back out of the way so that the packages could travel up over the head and down through the unloading point on the upper deck until they reach the unloading point on the lower deck, where the fingers are always fixed in position. In order to hinge the fingers, the angle-irons are attached to cast-iron hubs that are keyed to shafts.

Each of these machines is driven by a 5-hp. motor, operating at 900 r.p.m. and wound for a 220 volt, three-phase, sixty-cycle, alternating current. Each motor is equipped with a solenoid brake so that the machine can be stopped quickly when desired. The drive from the motor to the first countershaft is by means of silent chain and wheels, this countershaft being geared to the next countershaft by means of cut spur gears. The second countershaft is, in turn, geared to the headshafts by means of cut spur gears, these gears being cast as rings without arms or hubs and the rings being bolted to the sprocket wheels on the headshafts. The sprocket wheels are bushed with bronze bushings and run loose on the headshafts. The countershaft next to the motor is 2$\frac{3}{16}$ in. in diameter, the other one 2$\frac{7}{16}$ in. in diameter, and the headshafts are 4$\frac{7}{16}$ in. in diameter. The electric-control system is arranged with push buttons for starting and stopping the machine.

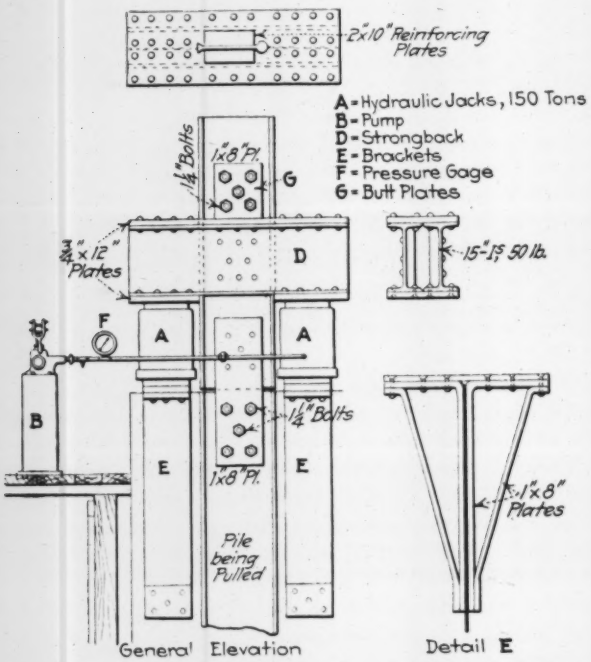
This equipment makes a very efficient system for handling packages of various kinds. The machines tend to act as pacemakers for the stevedores and keep them constantly at work on one deck without the necessity of their going back and forth from one deck to another. The machines were installed by the Link-Belt Co., under the direction of John Meigs, at that time Director of Wharves, Docks and Ferries. George W. Norris was director at the time the piers were designed, and George S. Webster is the present director.

Field and Office

Pulling Steel Sheetpiles from Earth-Filled Coffer-Dam

By D. A. Watt*

In the construction of the new lock and dam across the Hudson River at Troy, N. Y., a part of the river was laid dry behind a coffer-dam made up of steel sheetpiles driven to form cells which were filled hydraulically with sand and gravel from the river channel. The pockets, or cells, had a width of 24½ ft., a length of 24 to 32 ft. and a depth varying from 20 to 40 ft. About 3,170 piles were used, and when the coffer had served its purpose they all had to be drawn. The piles were of the United



RIG USED IN JACKING LOOSE STEEL SHEETPILES FROM TROY COFFER-DAM

States section, made by the Carnegie Steel Co. of Pittsburgh, Penn.

In this operation, owing to the tension in the interlocks, each pocket had to be "broken" by raising one pile with hydraulic jacks until its friction became reduced enough to allow the removal to be completed with shear legs. The latter were mounted on the bow of a derrick boat and were capable of exerting a pull of perhaps 40 or 50 tons. They were used to lift out the remaining piles until some were reached where the friction became comparatively negligible, whereupon the rest were pulled by a derrick boat with ordinary rigging.

The pile selected for jacking had to be on the outer face, so that the pulling boat could reach it later, and the closure piles were avoided as it was found that the friction on them was excessive.

*Principal Assistant Engineer, United States Engineer Office, Albany, N. Y.

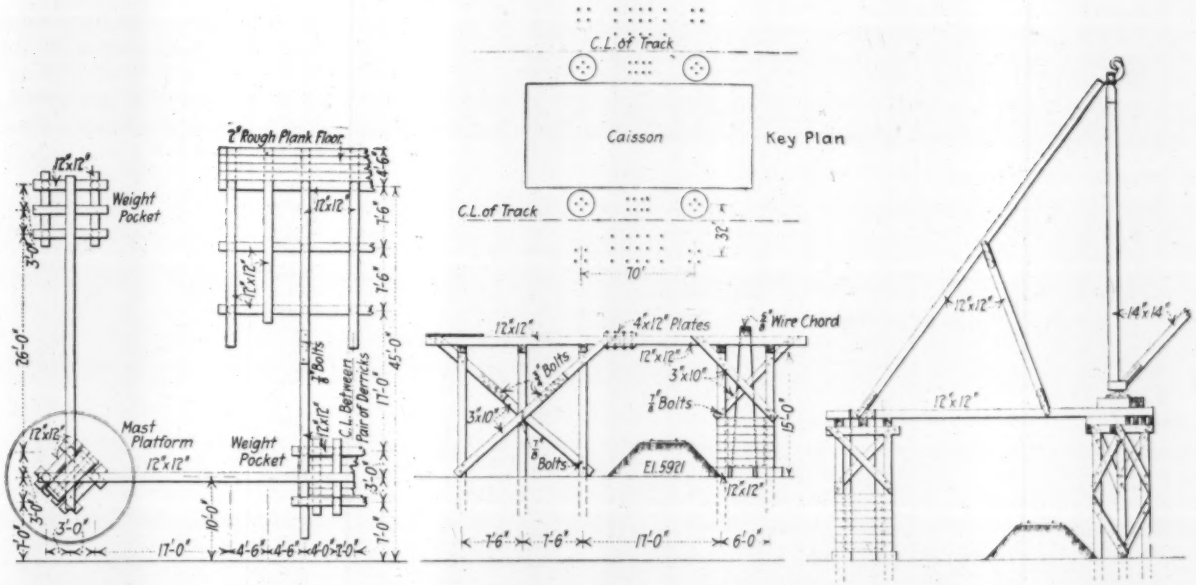
The pulling device is shown in the accompanying drawing. Two hydraulic jacks of 150-ton capacity each were used, mounted on heavy bar-iron brackets resting one on each adjoining pile. Across the jacks a strongback was placed with a short extension pile passing through it, bolted to the pile below. After each lift of the jacks, blocking was placed under them and another lift made; if the blocking became too high before the pile became "easy," it and the extension pile were removed, the jacks were put back on the brackets, the 1x8-in. bearing plates were attached to the main pile, and the jacking was resumed.

The jacking of these key piles took from one to several days (including the time for fitting up, drilling, etc.), depending on their obstinacy. In several instances the pile chosen had to be abandoned and another one tried, as the bolt holes would elongate in the web and sometimes tear out its end. The limiting pulls for starting varied from 25 to 190 tons per pile; but in a few cases, where the driving had been tight, the pockets could be broken by the shear legs, and no jacks were used. A flux of kerosene and engine oil was frequently poured down the interlocks in order to assist the jacking.

Several other methods for removing the piles were experimented with, but that described above was found to be the most satisfactory. Thus, an inverted steam-hammer hung from a derrick was used in several cases; but the breakages of the hammer rendered the method slow and expensive, and with obstinate piles no effect could be produced. A toggle arrangement was also tried in order to avoid having to drill the webs for the 1x8-in. plates, the toggles being hinged to side bars that straddled the pile and rested on the jacks, following them up or down. The toggles gripped the piles satisfactorily; but under a heavy strain they tended to crush their tool-steel faces, and their use was finally abandoned. With piling driven for deep sheeting and out of the reach of the boats, the most satisfactory results were obtained by using the powerful shears taken off the derrick boat and set on the ground. Where these failed to get a pile, as happened in a few cases, it was abandoned. In pulling the piles the best record for one boat in 8 hr. was 58, and the general average for one boat in 8 hr. was 12.

Double-Derrick Platform for Large Caisson Job

In sinking a large open-dredging caisson for the substructure of the Lifton pumping station of the Utah Power Co. at Bear Lake, Utah, the Jarrett-Chambers Co., contractor, used two sets of double derricks for the timber erection and excavation. As the caisson is high out of the ground at the start and when the second build-up is added, the derrick platforms are placed 15 ft. above ground. This height permits running a material track under the platforms. Timber for the caisson was brought in on the track, and, later, excavation spoil was carried away.



PLATFORM FOR TWO DERRICKS FOR FRAMING AND SINKING OPEN-DREDGING CAISSON
Designed and built by Jarrett-Chambers Co. for substructure caisson of Lifton Pumping Station, Bear Lake, Utah

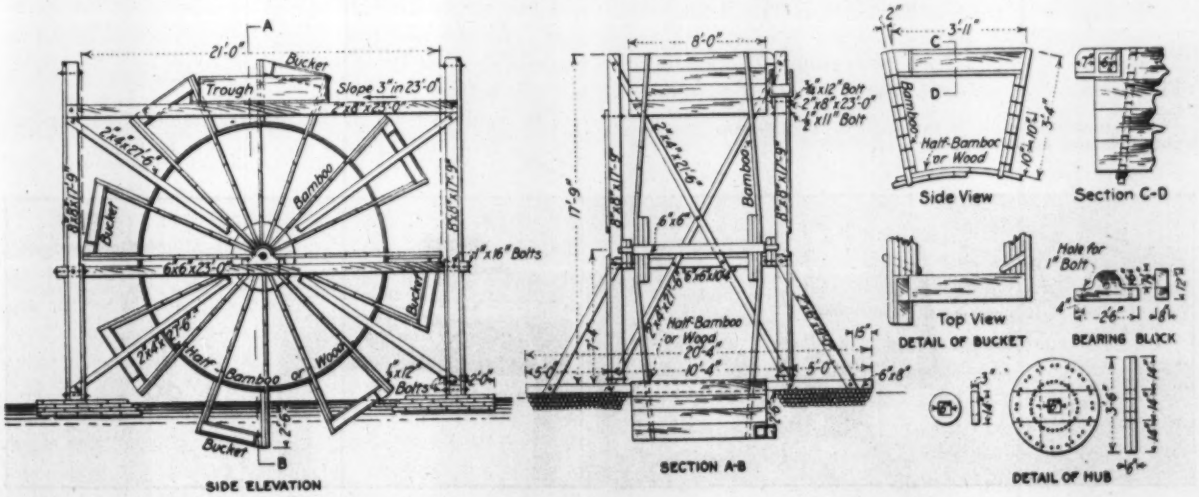
The drawing shows the construction of a platform for two derricks, with three weight pockets to tie down the stiff-legs. The mast load is taken by a four-pile tower, braced by diagonals. This tower being very close to the side of the caisson, flows of ground during the sinking produced settlement of the tower on one or two occasions. Except for this the derrick structure was stable and satisfactory throughout. The soil, a fine sand tightly packed, was able to carry large pile loads.

Light Home-Made Waterwheel for Irrigation

The Cotabato River in the Province of Cotabato, P. I., at low stages is from 10 to 20 ft. below banks, and the average velocity of the current is 3 mi. per hr. A waterwheel built cheaply and intended to serve as a pattern for the Moros was recently placed at Kudarangan. The current is used to raise water to irrigate land belonging to the agricultural school of the district. This wheel is described by A. E. Haley, District Engineer, in the *Quarterly Bulletin* of the Bureau of Public Works, Manila.

When the wheel was first erected, it revolved so rapidly that spokes were torn from the hubs and a large amount of bracing was necessary to prevent its being destroyed. The wheel is set on A-frames that rest on rafts anchored in the river in such a way that the wheel revolves in flowing water between them. The wheel consists of two parts, each having 16 bamboo spokes set in a hub 24 in. in diameter. The hubs are set 9 ft. apart on a 6-in. axle, and the spokes are nearly 8 ft. apart in the perimeter of the wheel. The paddles are formed of 12x¾-in. boards 8 ft. long. The buckets are of bamboo set diagonally and alternately between the paddles, so that there are eight in the wheel.

Measurement showed that the wheel lifts about 25 gal. per min. or 40,000 gal per day, when operating in water flowing at 3 mi. per hr. Each bucket carries 4 gal. of water, and the wheel makes a complete revolution. A revolution requires 70 sec.



THIS DESIGN WAS DEVELOPED AFTER VARIED EXPERIENCE, AND IS RECOMMENDED FOR LIGHT IRRIGATION WORKS

Experience has demonstrated that future wheels for this service must be more strongly constructed. A bamboo wheel is soon torn to pieces by the current. The wheel shown in the sketch is of more substantial design than the one described, and is recommended to rice growers. It has eight buckets, is strong enough to stand a 3-mi. current and should irrigate about 4 hectares of land on a 10-ft. lift instead of 1.5 hectares on a 17-ft. lift, as did the older wheel.

Mill Creek Sewer Tunnel Alignment Survey

By R. C. Gans*

The Mill Creek relief sewer in St. Louis, just completed, is a 16½-ft. lined tunnel through solid rock. Following an irregular street layout, it is very tortuous, having in its 18,000 ft. of length a total curvature of 905° with radii varying from 85 to 400 ft., most of them less than 200 ft.

The shafts on this tunnel vary from 1,600 to 4,000 ft. apart, and the length of shaft in the direction of the tunnel was rarely over 12 ft. It was therefore necessary to employ unusual precautions to secure accuracy of alignment.

The final survey was made in August, September and October, 1914. The survey party consisted of the engineer in charge, an instrumentman, three tapemen and a helper. The transit used was a Buff & Buff theodolite, the vernier reading to 10″. The 100-ft. steel tape was a Keuffel & Esser flat-wire "standard" tape without intermediate graduations. The tape was always made level, and passed over adjustable supports at the middle and quarter points. Temporary station-marking tables were used. These were 4-lb. cast-iron disks on three short supporters and bearing an adjustable point. After the head table was set, the rear table was carried forward and used as the head table.

In order to obtain an unbiased check measurement a stationary point was set only every 1,000 ft., or at a change of direction. After trial an allowable error in chainage of 0.02 ft. in 1,000 ft. was adopted, and we had comparatively little difficulty in keeping within this limit. At curves the work was checked by triangulation. In many instances the center line passed under buildings or car tracks, thus making important points inaccessible, which required extra checks.

The survey was marked by permanent monuments (Fig. 1) placed at convenient intervals, such as summits, intersection of tangents at reverse curve, near the shafts.

The center line was first established in the tunnel by means of two plumblines in the shaft and maintained by means of screw-eyes set in plugs in the roof of the tunnel. When the heading had been driven about 300 ft. from the shaft, the center line was again established by setting

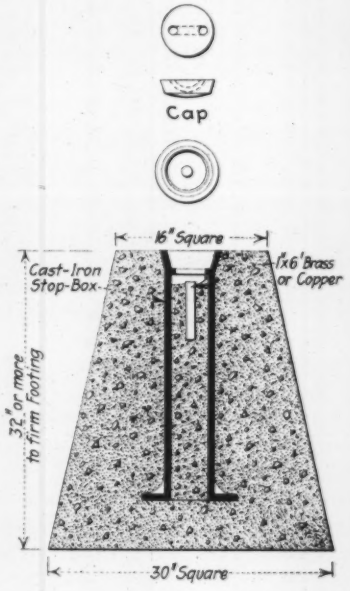


FIG. 1. PERMANENT SURFACE MONUMENT

one plumbline in the shaft and one in a drillhole near the heading, which had been previously drilled for this purpose. Fig. 4 shows the relative location of shafts and drillholes. Fig. 3 shows two views of the plumbing device and reel as placed at a drillhole. At a shaft they were usually placed on the shaft timbers. The plumb-bobs were 11½-lb. cast-iron weights suspended in oil. The plumbline was No. 12 piano wire. For underground work a transit of Berger & Sons manufacture was employed.

The drillholes above mentioned were 12-in. cased to solid rock, and 10 in. uncased through the rock. The contract for these holes required that they clear a plumbline. Seventeen holes were ordered drilled; the contractor lost three through failure to meet the above requirement, and two others were abandoned on account of failure to shut out water with the casing. The holes were tested by suspending a candle in a funnel reflector, or a flashlight, near the bottom of the hole.

The results shown in the adjoined table of survey-line closures prove the value of the precautions taken.

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FIG. 2. SURFACE MEASUREMENT FOR MILL CREEK SEWER TUNNEL, ST. LOUIS

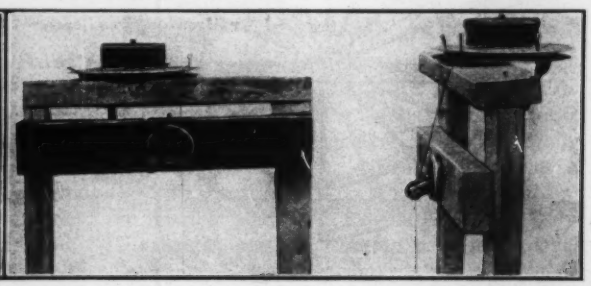


FIG. 3. PLUMBING DEVICE WITH SCREW ADJUSTMENT USED AT DRILLHOLES

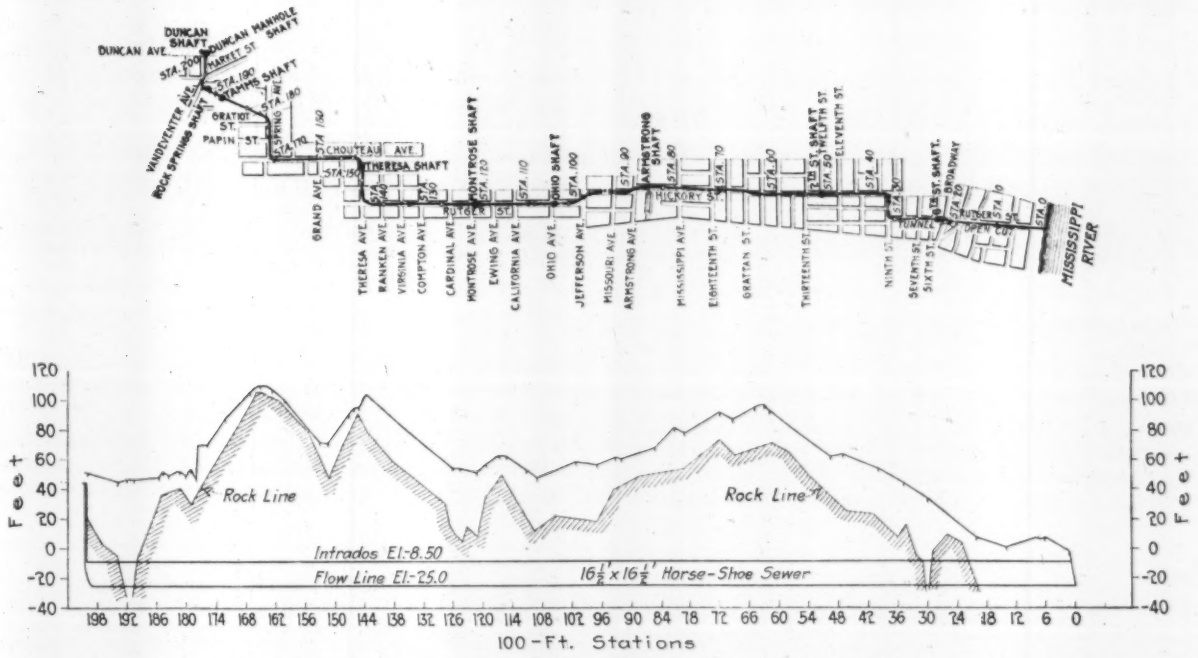


FIG. 4. LOCATION MAP AND PROFILE OF MILL CREEK SEWER OF SHAFTS AND DRILLHOLES

SURVEY-LINE CLOSURES AT JUNCTION OF HEADINGS

Headings	Lengths of Tunnel, Ft.		Error at Meeting Point, Ft. In Line	In Distance
Sixth St. and 12th St.....	1,400	1,400	0.002	Not measured
12th St. and Armstrong..	2,000	1,500	0.015	0.03
Armstrong and Ohio.....	1,300	600	0.12	0.08
Ohio and Montrose.....	500	1,100	0.05	Not measured
Montrose and Theresa...	1,500	1,500	0.16*	Not measured
Theresa and Tamm.....	1,900	1,900	0.025	0.005
Tamm and Rock Spring.	270	130	0.025	0.03
Rock Spring and Duncan	40	800	0	0.035

*In the heading south and east from Theresa shaft an error was known to exist when we passed a drillhole on Rutger east of Theresa. This error was not expected to exceed 0.2 ft. at the meeting point, and no attempt was made to eliminate it.

Methods of Enlargement Work in Rogers Pass Tunnel

By H. P. Tracy*

The ingenious drilling and blasting system used in the Rogers Pass tunnel of the Canadian Pacific Ry. had much to do with the phenomenal speed of advance attained by the enlargement excavation. The following description supplements the accounts of the Rogers Pass work given in *Engineering News* of Nov. 11, 1915, p. 920; Jan. 6, 1916, p. 42; Feb. 24, 1916, p. 382; June 1, 1916, p. 1034, in which articles the use of the pioneer tunnel and crosscuts to the line of the main tunnel was fully set forth.

The tunnel, now nearing completion, is 26,400 ft. long and provides for two tracks. Pioneer tunnels were driven from each end 50 ft. to one side of the main line and were stopped when they were 5,202 ft. apart. From these small pioneer drifts, crosscuts were run to the main line at intervals of 1,500 to 2,000 ft., thus affording numerous points of attack along the main-tunnel line. From the crosscuts a heading 11 ft. wide and 9 ft. high was opened up, on a level 6 ft. above the completed tunnel floor. From this heading the work of enlarging to full size was conducted.

*Denver Rock Drill Manufacturing Co., Denver, Colo.

In the enlargement the method followed was to drill a ring of holes (Fig. 2), the rings being drilled 5 to 6½ ft. apart. To determine the correct angle for drilling the holes, a clinometer was employed when pointing the drills. This clinometer board, or "clock," as it is called by the drillers, is made of $\frac{3}{16}$-in. sheet iron 12 in. square, with a handle riveted on the upper edge. As shown in the sketch, there is a pendulum hanging from one of the upper corners. Graduations on the

FIG. 1. RING DRILLING IN MAIN HEADING

board show the angle at which each hole must be drilled, and at the lower end of each graduation is a number showing the length of steel to be used in finishing that hole. After setting the board on the shell or drill, the drill was tilted until the pendulum reached the proper angle, when the drill was clamped. A different board was used for each arm of the drill column. When enlargement work was first started, the rings were drilled 6 ft. apart. It required

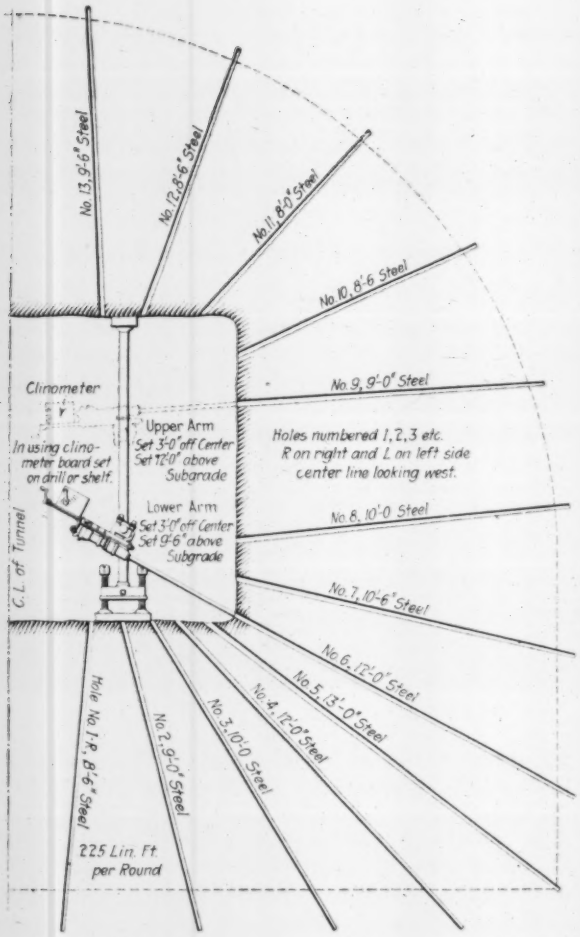

No. 13, 9'-6" Steel
No. 12, 8'-6" Steel
No. 11, 8'-0" Steel
No. 10, 8'-6 Steel
No. 9, 9'-0" Steel
No. 8, 10'-0 Steel
No. 7, 10'-6" Steel
No. 6, 12'-0" Steel
No. 5, 13'-0" Steel
No. 4, 12'-0" Steel
No. 3, 10'-0 Steel
No. 2, 9'-0" Steel
Hole No. 1 R, 8'-6" Steel
225 Lin. Ft per Round
Clinometer
In using clinometer board set on drill or shelf.
Upper Arm Set 3'-0" off Center Set 12'-0" above Subgrade
Lower Arm Set 3'-0" off Center Set 9'-6" above Subgrade
Holes numbered 1, 2, 3 etc. R on right and L on left side center line looking west.
C.L. of Tunnel

FIG. 2. COLUMN AND DRILL SETTING IN RING DRILLING, ROGERS PASS TUNNEL

The use of the clinometer board is an essential feature

a great deal of powder to spring the holes, and therefore the distance between rings was reduced to 5½ ft. This necessitated less springing; when later on they reduced the distance between rings to 5 ft., they found they could dispense with springing entirely, with a corresponding large saving in powder.

One of the clinometer boards in use is shown in Fig. 1. The drill runner with the machine on the second column in the foreground is shown pointing his drill with the aid of one of these boards. Denver "Dreadnaught" valveless water hammer drills were used.

This method of enlarging permits the employment of a large battery of drills all along the line of the tunnel. It has resulted in remarkably rapid progress, not only as to drilling, but also as to mucking, for it facilitates the use of the shovel by blasting out the tunnel to full section with every ring of holes fired.

The funnel being large enough to accommodate two standard-gage tracks, the shovel operated from one track while the muck cars were backed in alongside on the other. Two high-pressure compressed-air locomotives in each end took care of the haulage. They have a storage capacity sufficient to carry them one mile with a regular load, and 2-in. high-pressure air mains in the tunnel provide air stations about 2,000 ft. apart.

The force for mucking out each end is as follows for each shift: 6 men scaling, trimming and loading rounds ahead of shovel; 1 engineman and 1 craneman on the mucking shovel; 10 to 12 pitmen at the shovel; 1 general foreman; 1 foreman and 12 to 15 laborers for the dump and track work; engineers and brakemen, 1 fireman, 1 steam conductor and 2 repair carmen for the hauling locomotives and cars.

The contractors for the tunnel are Foley Brothers, Welch & Stewart, of Winnipeg; A. C. Dennis is their Superintendent. The work is under the direction of John G. Sullivan, Chief Engineer, Canadian Pacific Ry., and W. A. James, Engineer of Construction.

NOTES

Flat-Cars with False Floors for Dumping have been used in grading an extension of the logging railway of the Crossett Lumber Co., at Crossett, Ark. The arrangement was devised by J. R. Horton, Roadmaster for the company. The construction train consisted of three flat-cars, the middle one carrying a light revolving steam shovel or railway ditcher. Each of the other cars had a 14-ft. floor built up in two longitudinal sections 7 ft. wide. Timbers on the bottom raised the platform clear of short stakes in the stake pockets, and on each side one of these timbers rested just inside the line of stakes.

Plumb-Line Reflector—A useful and easily constructed reflector for use in underground surveys or for night work can be made as follows: Take a piece of any good strong wire and bend it in the form of a circle with a handle attached, and fasten a piece of tracing cloth over it, after the manner of a drum head. This device, when held back of a plumb bob and string with a lamp behind it, will diffuse the glare of the light and give a perfect shadow for a sight.—"Coal Age."

A Good Way to Blast Pole Holes is to put down a borehole almost as deep as the pole hole is to be, and tie small charges of dynamite at intervals of several inches to a straight stick or lath, which is placed in the borehole. The topmost charge is primed with a blasting cap or fuse. Forty per cent. or stronger dynamite should be used. It is preferable to spade out the surface to a depth of several inches before firing.

A Road-Patching Machine is used by the Los Angeles County Highway Commission for repairing bituminous-paved roads. The machine consists of a tank and firebox for keeping the oil at such temperature that it can readily be pumped and sprayed with a small hand pump. Three men operate this machine; one pulls it, one operates the small hand pump at the rear and the third handles the spray hose. The oil is

PATCHING MACHINE FOR BITUMINOUS PAVEMENTS USED BY LOS ANGELES COUNTY

first heated in a large vat and carried in buckets and poured into the front end of the machine. Wherever a patch is required the road surface is picked out to a depth of 4 or 5 in. and the hole thoroughly cleaned. Broken stone is then placed in the patch and rolled with a steam roller. Oil is sprayed over the surface, covered with screenings and rerolled.

Editorials

Engineers Can Vouch for This

When a private concern wishes to engage an engineer its main concern is to get the best man he can find for the job. With most cities other considerations come first. Only one of these will be considered here and that but briefly. This consideration, which is one of the worst in the lot, is the local residence requirement. How this makes for inefficiency, not merely in the particular city, but also throughout the whole country, is set forth under five heads in a recent number of "The Public Servant." Says Prof. Clyde L. King of the University of Pennsylvania:

> The local residence requirement for public office (1) tends to perpetuate mediocre technical and expert service, (2) means the continuation of party spoils, (3) makes impossible adequate training for all experts and (4) a national supply of experts, and (5) is therefore one of the biggest obstacles to the American ideal of an efficient democracy.

Even a large city, with an abundance of technical men to draw from, makes a mistake in barring non-residents from public office, because it lessens its range of choice and deadens the ambition of local men, whether in or aspiring to municipal positions. The case grows worse as the size of cities diminishes. It is for the interest of good government and of the engineering and other professions as well that the dwarfing effect of local residence requirements be abolished and that every city be free to select the best man the country affords for each position to be filled.

May Peace Be Purchased at Too High a Price?

The nation has witnessed an unprecedented spectacle during the past fortnight. There have been assembled at Washington the heads of the brotherhoods of railway trainmen and over a hundred railway presidents and managers, discussing with the President of the United States the demand made by the brotherhoods for an increase in wages.

The issues at stake are great for both of the parties to the controversy, but they are greater for the public at large. The sums immediately involved in the controversy are vast. Estimates vary from $50,000,000 to $100,000,000 per annum; but this sum is small in comparison with the amount which the public will have eventually to pay as a result of the precedent established if the present demands are granted.

For if the railway engine-drivers and firemen and conductors and brakemen, merely by the threat to bring about a nation-wide railroad strike, can add $50,000,000 to their wages, while they refuse to debate the question whether they are fairly entitled to such an increase or not, it is safe to say that similar action will be taken by other bodies of railway employees. Such action would be justified, moreover, since these other employees are receiving lower rates of wages in proportion to the work done and the responsibility carried than are the trainmen.

It has been plainly evident in the negotiations at Washington that the chief party in interest—to wit, the public—is largely ignored. The railway presidents have been reported as willing to grant the demands of the trainmen, provided they could receive absolute assurance from the President and Congress that a rate increase would be permitted sufficient to repay the companies for their added outlay in wages. In other words, if they were allowed to collect from the public the sum demanded by the trainmen, they were willing to give in. They should not be too severely blamed for this, for they have been fighting the public's battles a good while and receiving no thanks.

For one thing the railway officers cannot be too highly commended, and that is for their strong support of the principle of arbitration of industrial disputes. The brotherhood officers, on the other hand, deserve the severest condemnation for their absolute refusal to submit their case to arbitration.

The responsibility of defending the interests of the public in this great controversy has fallen upon President Wilson; and apparently because of his belief that a strike must be prevented at any cost he has failed to realize that peace may be purchased at too high a price. When the railway presidents urged him to accept and apply the principle that all industrial disputes should be submitted to arbitration, he could not of course deny the soundness of the principle, but he declared that arbitration was impossible because the brotherhoods would not accept it!

It is time for men to stop and inquire seriously where we stand, when an organization demands that the public hand over to its members a round fifty million dollars a year, refuses to arbitrate the question whether it has any just claim on such a sum and announces its intention of stopping railway-transportation lines throughout the country unless its demands are granted forthwith. Where shall the interests of the public find a defender when the President of the United States insists that this demand must be granted, not because it is just, but because of the dire results that will follow if the threat is carried out? Can any right-thinking man justify such a threat? It differs from the threat of the highway robber only that it is made on a vastly larger scale, for it is a hundred million persons who are held up instead of one.

Engineering News has for more than 30 years been a prominent and outspoken advocate of better economic conditions for the great mass of the people, and especially for those who labor with their hands. It has taken a leading part in the long struggle to establish Government control of public utilities and measures to prevent public oppression, monopoly and other abuses by combinations of capital. It recognizes the right and the necessity of labor organizations to protect labor from injustice and oppression; but it unhesitatingly condemns the attempt of combinations, either of labor or of capital, to exact from the public, under threat of violence, anything to which they are not willing to prove their right before an impartial tribunal.

Undoubtedly a large part of the public has a false idea of the controversy. They view it as merely an attempt of a certain group of workingmen to get higher wages from their employers, the railway companies. But while there may be temporary loss of railway-company profits if this and other demands for higher wages are granted, it is certain that the railways must continue to be operated, and the public must pay the entire cost of operating them, with enough profit besides to induce people to invest their savings in additional railway facilities. In the long run, therefore, it is the public and not the railway stock and bond holders who must give up the millions which the trainmen demand, if the railway presidents yield.

The public is sadly astray, too, on another aspect of the controversy, and for this also President Wilson is chiefly responsible. It is he who has beclouded the public mind with the idea that what the men are fighting for is the eight-hour day. He said in his statement to the public on Aug. 19:

> I have recommended the concession of the eight-hour day because I believe the concession right. The eight-hour day now undoubtedly has the sanction of the judgment of society in its favor, and should be adopted as a basis for wages.

In this statement, destined to be widely quoted everywhere for years to come, whenever a controversy over the hours of labor arise, the President says *in words* that he supports the eight-hour day in order to settle the dispute; but the proposition which he has asked the railroads to accept has *nothing whatever in it to establish the eight-hour day.* What he asks the railways to do is to increase the hourly rate of wages so that they would pay as much wages for eight hours' work as they now pay for ten hours. He omitted the brotherhoods' original demand for a time-and-a-half rate for overtime work. Hence under the arrangement which he proposes, the railways would have no incentive whatever to reduce the present working hours of the trainmen.

An elementary arithmetical computation shows that increasing the hourly rate so that a man earns as much in eight hours' work as he formerly earned in ten hours' work is equivalent to an increased wage rate of 25%.

If President Wilson believes that the eight-hour day is the real question at issue, then he must believe that a large proportion of the trainmen who are making these demands are working much longer than eight hours and would therefore be entitled to this large increase in their wage rate. Yet he demanded that the railways should put his proposition in force and give it a trial because, forsooth, no one is wise enough in advance of such a trial to determine whether the cost to the railways would be material!

President Wilson declares that society favors the eight-hour day. If he means by that statement that the majority of voters favor the general principle of the eight-hour day as a movement toward bettering the conditions of the workingman generally, he is very likely right. It is true also that the best experts on efficiency in production are generally agreed that where employees are working day in and day out the year round, in industries requiring intense use of nerves and muscles, such as factory work under modern high-pressure industrial conditions requires, eight hours is as long a working day as the average employee can stand and continue efficient work. But the railway brakeman, while he is on duty, has little or nothing to do so long as the train is in motion. He has not as strong a claim for the eight-hour day as the workman in the car shop or the laborer in the section gang.

If President Wilson means that society favors the universal eight-hour day as a practical working proposition, he is on unsafe ground. Everyone concedes the desirability of a shorter working day if the greater leisure it affords is rightly used; but most people prefer to work longer hours in order to earn more money and be able to buy more of the things they want. The railway trainmen themselves do not want shorter hours, but larger wages for their present working hours.

In deciding the momentous question whether or not to grant the demand of the railway brotherhoods it is proper of course to forecast the results if the demand is refused. The body of railway officials in Washington is best qualified to judge as to the extent of the difficulties which will result if the brotherhoods carry out their threats. It is very doubtful whether other classes of railway employees would sympathize with and support such a strike. The Pennsylvania R.R. claims to have a list of volunteers from other classes of its employees sufficient to fill the vacancies in the train service twice over if all the men threatening to strike should go out.

There is some reason to believe, also, that a large proportion of the members of the trainmen's brotherhoods have regarded the whole matter as a big game of bluff on the part of their officials to get something for them, which of course they would be very glad to have; but when it actually comes to the pinch, they will be slow to actually forfeit the lucrative positions they have so long held.

If the strike comes, there will be in all probability, for a few days and perhaps for weeks, much disorganization of train service and resulting hardships and suffering of innocent persons. Yet is not the sacrifice justified? Shall any organization be permitted to exact contributions from the public in proportion to its ability to cause disaster if its demands are refused? That way lies anarchy.

How the Misfits in Professional Education May Be Avoided

Many readers will recall the admirable article condemning over-specialization in engineering education, written by Prof. W. A. Wilson, of the University of Illinois, and published in *Engineering News* of Dec. 23, 1915. Elsewhere in the present issue Professor Wilson discusses the question of how professional misfits in engineering may be avoided.

It is unfortunately the case, as most engineering teachers of experience are aware, that a very considerable percentage of the boys now studying in engineering schools, although they may go through the prescribed routine of studies and pass the required examinations, are not naturally fitted for engineering work. This is of course no new condition; but in the early days of engineering education it could be said with a fair approach to truth, that if the youth did not follow engineering he was getting a good training and education which would be of advantage to him in any occupation he might take up.

It must be admitted that this is not true at the present day. Engineering courses have become more technical and specialized. The demand for the inclusion of the

technical and the special has resulted in cutting down the time devoted to culture studies. For these reasons it is difficult to believe that the boy who spends four years in a first-class engineering school but does not thereafter follow some branch of engineering uses his time to the best advantage.

Professor Wilson calls attention to a grave defect in our educational system, but it is doubtful if the remedy he proposes for it is sufficiently radical. So long as the American public implicitly holds to the belief that the business of higher education is to impart specialized information on every subject under the sun, from computing bridge stresses by the latest short cut to training a hen to lay 200 eggs a year, or writing advertisements for liver pills—so long will the higher education prove a huge disappointment to many of those who invest time and money in it. This does not mean that there is not room and place for the vocational school, but that the first aim of higher education should be to fit the student for whatever occupation he may have to follow in life, and not for the one particular niche that he may never be able to fit.

Locations for the Government Nitrate Plant

A number of cities located in different parts of the country are each bringing to bear all the influence they can command to secure the location in their vicinity of the Government nitrate plant authorized by the National Defense Bill which became a law on June 3. Apparently, however, the selection of a site or sites for the plant is not likely to be made for some time yet. The Bureau of Ordnance of the War Department, in conjunction with a committee of the National Academy of Sciences, is investigating the different processes for the production of nitrate and the final selection of the process may influence the choice of a site.

At the outset it appeared to be generally assumed that the Government would concentrate the entire nitrate production authorized by Congress at one plant. Further study of the problem, however, indicates that there would be material advantage in scattering the production among a number of plants located in different parts of the country. The primary object of the plants is national defense, and there would be an obvious advantage in having a sufficient number of these plants so that the capture of one or two of them by an invading enemy, or their accidental or premeditated destruction, would not be sufficient to entirely destroy the country's facilities for producing explosives.

While the production of material for explosives for use in national defense is the primary purpose of these plants, they will have sufficient capacity so that except in the event of actual war at least nine-tenths of their output will probably be marketed in the form of artificial fertilizer. In this form, however, the price at which the product can be sold will be largely governed by the cost of transportation to the final users, and half a dozen plants in different parts of the country each supplying the farms in the territory surrounding it, would yield a far better commercial return and would be far more beneficial to the agricultural interests than if the entire output of nitrate were produced at one plant.

There is indeed a possibility that such considerations as proximity to raw materials or to markets which could take the product for use in connection with other fertilizer materials or other chemical industries might determine the location of the plant at a site where power could be developed from cheap fuel. The more likely supposition, however, seems to be that a site or sites will be chosen where the Government owns water power produced through the improvement of rivers for navigation.

Eliminating Cost of Transfers on Through Routes

In *Engineering News* of July 20 an explanation was given of the fight which cities on the New Jersey side of the North River are making before the Interstate Commerce Commission against being compelled to pay for lightering freight across the North River, as shippers in New York City have to do.

Through the courtesy of Frank L. Neall, of Philadelphia, we have been favored with a copy of a letter written in 1889 by the late Col. Joseph C. Potts, of Philadelphia, a prominent civil engineer and financier of that day, to Hon. James A. Logan, at that time Assistant General Solicitor of the Pennsylvania R.R. In this letter Colonel Potts reviewed the gradual elimination of transfer charges on through east and west traffic as follows:

> There was a time when all goods movement between New York and the West passed, necessarily, through the hands of forwarders at Buffalo, and when all similar movements between Philadelphia and the West had a similar experience at Pittsburgh. Forwarders at both points were originally improvements. They effected transfers and dispatching of goods, with less cost and friction than the owners of the goods could themselves have done. But as carriers advanced in skill and scope, they combined their operations, so that transfers with their delays and outlays began to disappear. A new economy arose, and the forwarder at many transfer points lost his value and became a costly excrescence. His business had been honorable, profitable and useful. He looked upon its excision as an oppressive outrage, and fought against such an issue with all his power. This contest has ended at Pittsburgh, and so far as traffic carried all-rail is concerned it has also ceased at Buffalo.
>
> At Erie, Penn., it was not the forwarder, but the whole population, who fought. In this case it was ostensibly to preserve a difference in gage, but really to preserve the small increment of profit arising from the services which the transfer enforced by this break of gage made necessary.
>
> It still rages to some extent in Chicago, and virulently now in New York. To the latter city, traffic passing between foreign countries and this has, for many years, flowed without much municipal effort and without much effective opposition to heavy local taxation in wharf hire, cartage and in numberless other forms, not illegitimate but fast becoming unnecessary.
>
> As inland and ocean carriers have now commenced the same forms of beneficent union which have grown up within the limits of this country, and with the same useful results, the forwarder and all who, while really merchants, are also quasi-forwarders, naturally wage the same sort of fight which inland transfer points have witnessed. But this new phase in New York is no reflection upon the past of those who now oppose the change. They lived useful lives and earned well their profits.
>
> Through rates and through bills of lading, however, are in the nature of new inventions. If they make commerce easier and cheaper, and thus lessen barriers to movement, they are valuable inventions, and the old methods must end. Their close will not be sudden; the two methods always work for a while side by side, but the improved method will increase, while the poorer one must decrease. This is inevitable.
>
> It is to be hoped the Interstate Commerce Commission will not ignore this great and controlling tendency. It cannot help but prevail. One of the most valuable functions of this commission is to perceive, sooner and more clearly than others who look from lower planes, the leading facts and motives around which all regulations of commerce, and the transportation branch of commerce, must shape and fit themselves.

Letters to the Editor

Repetitious Road Discussion

Sir—Hearty approval must be accorded your recent editorial comment and the letter of one of your correspondents on the failure of many of the papers read at road congresses to do more than deal with generalities.

At these meetings, whose great usefulness in many respects must be acknowledged, one can frequently predict from an inspection of the program the contents of many of the papers. There is always the discussion which begins with the statement, "The importance of good roads to a community is now very generally recognized," followed by an appeal to the engineers present to discover the perfect road which shall not wear. There is never missing the ingenuous soul who proclaims his discovery that maintenance is equally as important as care in original construction, and somewhere in the program is the practical man who casts ridicule on all written knowledge.

Last year, in outlining to a meeting of engineers some of the problems of paving in large cities, the writer commented on the difficulty of finding a highway discussion that did not start with, "Great changes have been effected by the introduction of the automobile, which has apparently come to stay."

Returning from an enforced pedestrian inspection, under the auspices of our War Department, of the possibilities of protecting our national Southern frontier, where streets are paved with only mud and cactus, the writer casually took up copies of the proceedings of some recent road congresses and opened them at random. On the earliest pages turned over were his old acquaintances, the standard platitudes; and in the first part of one volume, mainly devoted to serious discussion of construction methods, was our old unavoidable friend, "There is no longer any question but that the motor vehicle has come to stay."

But admitting the truth of your destructive criticism, it does not seem as if your constructive conclusions are as complete. It must be remembered that most of the road congresses serve at least two purposes. They are not only gatherings of technical men, interchanging ideas on road construction, but they depend very largely for their support, outside of that which they get from the supplymen, on the nontechnical public interested in good roads. Consequently there is justification for a good many of the generalities which strike the technical man as unnecessary. The papers of the latter should undoubtedly be improved by the elimination of the long statements of elementary principles of which you complain, but they should not thereafter be limited merely to a discussion of comparative details, valuable as these are.

There is plenty of room left for improvement in matters of organization, the larger policies of road construction and general questions of comparative merits of different types of pavement, and much of the very technical matter which would be all that would remain under your editorial restriction is of a nature too difficult to discuss in open meetings and more suitable for written comment.

The writer does not in any respect disagree with your comments. He believes that there should be more open publication and chance for discussion on mistakes, as well as on good work, but he believes also that there is much in general matters not sufficiently standardized to be still open for debate and to contain elements for discussion at future road conferences.

The suggestion made by your correspondent in the issue of Aug. 10 as to the importance of papers directed toward the standardizing of asphalt specifications is very timely and brings attention to the fact that if it were possible for those interested in such types of pavement as sheet asphalt and wood block to get together and spread scientific information in the way it is done by those interested in the construction of brick and concrete pavement, there would be less possibility for some of the accusations that have been made in the past in regard to the relations between paving interests and pavement designers.

HENRY WELLES DURHAM,
County Engineer, Bergen County, New Jersey.
Hackensack, N. J., Aug. 14, 1916.

Bituminous Materials Tests for Sheet Asphalt

Sir—In Mr. Forrest's comments on my article entitled "Bituminous Materials Tests for Sheet Asphalt," which appeared in your issue of Aug. 3, 1916, he states that he fails to find any reference to solubility in carbon disulphide in the American Society of Municipal Improvements' sheet asphalt specifications under the head of Refined Asphalt. Clause b of paragraph 4 of these specifications reads as follows:

> Ninety-eight and one-half (98½) per cent. of the total bitumen of all refined asphalts shall be soluble in carbon tetrachloride.

The definition for bitumen adopted in 1912 by the American Society for Testing Materials is as follows:

> Bitumens are mixtures of native or pyrogenous hydrocarbons and their nonmetallic derivatives, which may be gases, liquids, viscous liquids or solids, and which are soluble in carbon disulphide.

The method adopted by the A. S. T. M. for the determination of bitumen calls for the use of carbon disulphide as a solvent, which of course accords with their definition and also accords with the standard practice throughout the country and in Mr. Forrest's laboratory.

In other words, Clause b of the A. S. M. I. specifications calls for the determination of the total bitumen (which must be and always is made by determining the solubility of the material in *carbon disulphide*) and also the determination of the percentage soluble in carbon *tetrachloride*, otherwise the relation between the two as called for by this clause could not be established.

Paragraph 22 of the A. S. M. I. specifications describes the method for the determination of total bitumen in *refined asphalts* and asphalt cements and specifies the use of *carbon disulphide*. (The italics are mine.)

It appears strange, in view of the foregoing, that anyone with Mr. Forrest's experience in asphalt analysis should have been unable to see that this clause called for a solubility test in carbon disulphide.

I fail to fathom the connection between my article and the special committee (of which I am a member) appointed by the A. S. M. I. to investigate and develop methods of testing paving bitumens, but as Mr. Forrest has referred to it I may be pardoned for quoting from pages 768 and 769 of the "Proceedings" of the 1914 Convention of the A. S. M. I.

Mr. Tillson: I have a resolution I would like to present. I was asked to present it by Mr. Smith, of the Asphalt Committee.

Moved: That a technical committee be appointed by the president, consisting of five members, whose function it shall be to invite and direct the coöperation of all chemists dealing with bituminous materials for the purpose of further standardizing present methods of testing and for the purpose of encouraging and developing additional methods and appliances for valuating paving bitumens. This committee shall be permanent for a period of four years and shall report to the general organization at each meeting.

Mr. Tillson: I believe this is a good resolution, and would move its adoption.

Mr. Howard: I will second that. Asphalt testing has practically stood still for seven years, and I think this is a splendid thing.

Carried.

The thought behind this resolution was that the Society should endeavor to promote research along the lines indicated, to the end that whenever new tests of value were established they might be incorporated in the various specifications for bituminous materials adopted by the Society.

By his statement that it was appointed "despite the specifications which Mr. Smith supports so feelingly," Mr. Forrest would seem to intimate that this committee was suggested by some one outside of the Sheet Asphalt Committee.

F. P. SMITH.

131 E. 23rd St., New York City, Aug. 11, 1916.

Pile Formula for Double-Acting Hammer

Sir—In an article entitled "Pile Formula Modified for Double-Acting Hammer," appearing in your issue of July 6, a rule is stated for a general guide in determining the numerator of a formula for a double-acting hammer, derived from the *Engineering News* pile formula for a gravity drop hammer, as follows:

Ascertain as nearly as possible the foot-pounds represented by the blow delivered by the hammer. This can be done by adding to the foot-pounds represented by the free fall of the hammer the foot-pounds obtained by multiplying the mean effective pressure by the area of the piston and the length of stroke in feet. The result is the numerator of the formula.

While this statement in itself is entirely logical, it is not easy to apply with so high a degree of accuracy as one might infer after casually reading it. The formula given in the conclusion of the article, if stated

$$P = \frac{2(W + Ap)h}{s + 0.3}$$

(the 2 in the numerator was probably omitted unintentionally), is exactly what I had in mind in my letter published in your issue of Feb. 24, 1916.

The values of the terms p and h more than likely vary considerably at different times under different conditions for the same hammer, and it would therefore seem unwise to arbitrarily use the same value for these terms under these circumstances on account of variable conditions of practice.

The actual mean-effective steam pressure in the cylinder of the hammer depends upon the steam pressure at the boiler and the loss in the steam line during transmittal, the adjustment of the steam valves in the hammer and the back pressures allowed in order to have a slight lead to the valve to maintain the maximum number of strokes per minute, etc. On account of the last condition stated, there must be a variation in the actual length of the stroke of the ram for various speeds of operation.

It is assumed in the article in your issue of July 6 that the mean effective steam pressure in the cylinder is 25 lb., which may be approximately right, although most manufacturers rate their hammers on the pressure of 60 lb. The only means of determining what the actual effective pressure is is by indicator card readings, and it would not be practical to take these readings when driving piles in actual practice or to determine the actual stroke of the ram.

If, however, the effect of the combination of the steam pressure and length of stroke of the ram and the fall of the weight of the ram could be observed in some way, it would serve the same purpose.

It is evident that the work done by a double-acting steam hammer per blow or per minute in driving a pile should vary, not considering the effect of the fall of the weight of the moving parts, directly as the mean effective pressure; and upon the mean effective pressure and the weight of the ram depend the number of blows per minute, length of stroke and the velocity of the moving parts at the end of the stroke.

It would seem therefore that if the rating of a hammer (work per blow or per minute) was established by tests which would include the effect of the weight of the ram, either by some means of measuring the work done or calculating it from actual effective steam pressure shown by an indicator diagram, and the number of blows per minute or the velocity of the striking parts recorded for various speeds of operation of the ram, all it would be necessary to do to determine the actual work done on any pile by that particular hammer, provided its adjustments, etc., were the same as when rating was established, would be to count the strokes of the ram per minute which would correspond with an established amount of work done for that particular hammer, which divided by factor of safety six would represent the numerator in the formula.

Although the constant used in the denominator depends somewhat on the character of the soil through which the pile is driven, it also is supposed to depend on the rapidity with which the blows are delivered. If, therefore, in the steam gravity drop-hammer formula a constant 0.3 is considered proper as compared with 1 for an ordinary drop hammer, then it would seem entirely logical and proper to concede that a still lower constant should be used for the double-acting steam hammer, since the double-acting steam hammers deliver from 100 to 500 blows per minute, not allowing the pile to stop moving, while the gravity drop steam hammer delivers only about 60 to 100 blows per minute. How much this constant should be reduced could only be determined by comparative tests.

A. M. KNOWLES,
Asst. Engineer of Bridges, Erie R.R.

50 Church St., New York City, Aug. 18, 1916.

New Grooved Girder Rails

The recent introduction of round-topped girder rail sections on some large street-railway systems calls attention to interesting developments in the problem of the relation of wheel tread to rail head under street-railway conditions.

A few years ago the American Electric Railway Engineering Association adopted for grooved rails a flat-top head. But instead of making this level and using cylindrical wheels (as has been proposed for railway T-rails), it gave the top of the rail head an inclination of 1½° (ascending from the gage-line corner) in order to approximate that of the standard wheel tread: 1 to 25. Among the reasons for this were the claims of the manufacturers that it was difficult to roll large grooved girder rails with curved heads, except at increased cost, and that it was difficult to make this curve when grinding rail joints.

Results very different from those expected have been obtained in some cases, though it cannot be stated just how extensive these conditions are. On the Brooklyn Rapid Transit Ry., trouble developed with early corrugation in new rails, and particulars of the investigation have been made public by R. C. Cram, Assistant Engineer. It appeared that instead of uniform wear from the approximately identical contours of rail and wheel, the wear was concentrated along the inner edge of the head, adjacent to the top corner. A careful study of wheels then showed that the average tread was hollow, with a curve of about 16 in. radius on an incline of about 4°.

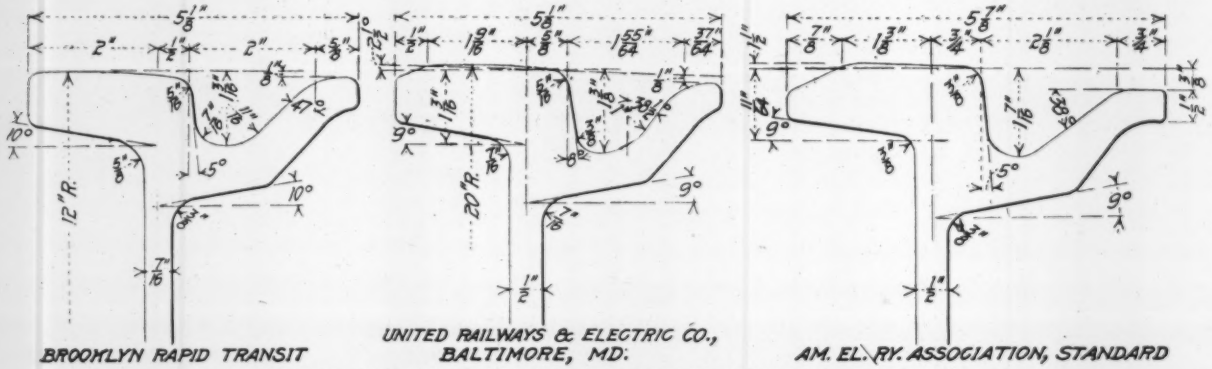
The rail head being inclined only 1½°, the wheel was practically clear of the rail except for a narrow strip along the gage side. The concentration of load, under heavy cars, resulted not so much in ordinary wear as in a cold-rolling which caused the metal to flow, this flow being both longitudinal and transverse. The latter movement was assisted by the angular pressure of the wheel tending to force the metal out on the corner and on the unsupported gage side of the head, where it was cut or ground off by the wheel flanges. This irregular displacement of the metal resulted in the development of corrugation of the rail head.

While similar loading and flow occurs on T-girder rails and ordinary T-rails it does not appear to cause corrugation, as in grooved rails. The explanation of this is that in T-rails the head is centered over the webs, while the head (not being stiffened laterally by the horizontal flange formed by the groove and guard of a girder rail) is more flexible and is free to move under the lateral movements and blows of the wheels.

As a result of the investigation, the rail manufacturers agreed to roll curved-head rails without increase in cost, no other change being made from the standard section. The mills have had no difficulty in rolling these rails with a uniform head contour, nor has there been difficulty in grinding the joints, even at compromise joints where the curved-head rails connect with flat-head rails.

The rail head thus adopted is shown in the accompanying drawing. According to a statement received from Mr. Cram, it was designed to reproduce as nearly as possible the average curved contour of the worn rail heads of this company's lines. In the first place, the object was to secure a greater range in the contact, with the view of spreading it out more quickly over the entire width of the rail head, and preventing its concentration continuously along definite areas.

It was also desired to have the wheel contact so located on the rail head that it would be farther back from the gage line and approximately over the center line of the web. The object of this was to prevent the flowing of metal over the gage line at the fillet or top corner of the head on the groove. It was thought that with this design, rail corrugation would not make its appearance so soon and might be prevented entirely. So far these objects seem to have been attained, but as yet no definite conclusion can be made, since these rails have been in use only eight months, and rails are sometimes in service for two years before corrugation begins to develop.



SECTIONS OF GIRDER RAILS WITH CURVED AND FLAT-TOP HEADS

As a result of his investigations, Mr. Cram arrived at the conclusion that the design of the inclined-plane form of rail head was based on a misconception of the conditions, and that the curved-head design meets the conditions by providing a wider zone of contact and so avoiding excessive pressure adjacent to the unsupported metal at the gage side of the rail head. The curved head will also eliminate the unnecessary wear which otherwise takes place while the rail and wheel are coming to a proper bearing. It is of special interest to note that he suggested that wheels might be made with a hollow tread to approximately fit the curved rail head. This is an interesting variation from the older suggestion of a cylindrical or flat-tread wheel to fit a flat-topped rail.

A rail of the same type, but differing in some details, has been introduced for similar reasons by the United

Railways and Electric Co., of Baltimore. This also is shown in the accompanying drawing, and information regarding it has been furnished by Mason D. Pratt, Chief Engineer. The early experience was that owing to the coning of the wheel treads (about 2½°), the new wheels on most rails had a bearing only adjacent to the gage line. Consequently the wear was excessive for the first two or three years, or until the wheels and rails were worn to a wider bearing.

To overcome this difficulty the top of the rail was inclined to fit the wheel tread, but the slope was about 2½°, instead of 1½° as in the design previously described. This inclined surface was flat, in accordance with the standard of the American Electric Railway Association. It was then found that owing to the fact that a large percentage of traffic on the suburban lines was carried by T-rails, the tendency of the wheel wear on the girder rails of the city lines was to slightly hollow the tread. This objection was met by giving a curved surface to the inclined top of the rail. This is shown in the drawing, which represents the company's present standard 7-in. girder rail. The wheels now have full bearing, and there is a material lessening of the early occurrence of corrugation which was due to insufficient bearing of the wheel upon the rail. There will be also some increase in the life of the rails.

In this Baltimore rail the top radius is 20 in. (instead of 12 in. for the Brooklyn rail), on an inclination of 2½° (instead of 1½°), and the top corner radius is $\frac{5}{16}$ in. (instead of ⅜ in.). The Baltimore rail also has a ½-in. web, 5½-in. base and 8° slope for the gage side of the head. The Brooklyn rail has a $\frac{7}{16}$-in. web, 6-in. base and 5° slope on the rail head. Both rails are 7 in. high and weigh 105 lb. per yd. The A.E.R.A. standard 7-in. rail, which is also shown, has a 6-in. base and ½-in. web, but the wider guard to the groove increases the weight to 122 lb. The horizontal distance from the gage line to the center line of the web is ¾ in. in the A.E.R.A. rail, ⅝ in. in the Baltimore rail and only ½ in. in the Brooklyn rail; one of the special objects in the design of this last rail was to reduce this distance as a means of checking rail corrugation.

Electric Pumping Plant for Land Drainage*

The electrification of a steam pumping plant is an interesting development on the Spring Lake Drainage and Levee District, in Illinois. The district has an area of about 12,500 acres, with 18 mi. of leveed frontage on the Illinois River and with a width of ½ mi. to 3 mi.

The drainage water is pumped over the levee to the river by a plant at the lower end of the district, about 15 mi. from Canton, Ill. This was installed in 1909. It consisted of two R. D. Wood 48-in. centrifugal pumps direct-connected to two Russell cross-compound engines, and a 24-in. Worthington pump direct-connected to a single-cylinder Russell engine. The speeds were 170 to 215 r.p.m. for the large pumps, and 250 r.p.m. for the small pump. Steam ejectors were used for priming the pumps. There were two water-tube hand-fired boilers of 300 hp., with a steam-driven induced-draft outfit. The difficulties in obtaining coal, keeping good operators and making emergency repairs led the commissioners of the district to adopt electric power.

Each of the large pumps is now driven by two 25-in. silent-chain belts from a Westinghouse 440-volt induction motor of 300 hp. The small pump is driven by a 10-in. chain from a similar motor of 100 hp. The sprocket wheels are placed on the pump shafts in the positions occupied originally by the flywheel and eccentrics. The controlling equipment consists of auto-transformers and three oil circuit-breakers of the switchboard type. For priming the pumps there is a small compressor used as a vacuum pump.

Power is furnished by the Canton Gas and Electric Co. over a 3-phase 60-cycle 13,000-volt transmission line. The wires are carried across the river (about 2,000 ft.) on four steel towers having four posts on concrete piers, the base of the tower being 3 ft. above high-water line. The substation at the pumping plant consists of four 25-ft. poles with lightning arresters, disconnecting switches, choke coils and fuses.

The specifications required that the pumps should be capable of being operated at two different speeds. This condition is met by providing two sets of motor sprockets to be fitted to the shaft in accordance with changes in the head against which the pumps have to work. The lower speed is used with low heads, and the high speed when the lift is near its maximum. (Two other chain-driven pumping plants for drainage work, in which speed-changing devices are used, were described in *Engineering News*, Sept. 23 and Nov. 11, 1915.)

The Spring Valley plant does not operate continuously, its work depending largely on the season and the rainfall. Heavy pumping is required for only about three months, 65 to 75% of the annual work being done between Mar. 15 and June 15. The remaining work is distributed about evenly through the other months. The usual load on the plant is 250 kw., and during a part of the year this load is on the lines about 10 or 12 hr. per day. During the time of heavy pumping the motors are operated sometimes 18 to 20 hr. daily. In extremely wet periods all the pumps have been in simultaneous operation for a few hours, taking about 600 kw.

The preliminary work on the electrification project was done by Hoppin & Rich, engineers, of Peoria, Ill., who made an investigation for the Canton Gas and Electric Co. At that time the company had no schedule of rates which could be applied to this class of service, and the schedule now in effect was devised by the engineers after a study of existing rates and the cost of power at the company's switchboard. The power is sold at a rate per kilowatt-hour per acre per month, depending on the amount of land served and the amount of power used. The cost of operation is said to compare favorably with that of the former steam operation, while the certainty and freedom from interruption have made the service satisfactory to the commissioners.

*From information furnished by the Westinghouse Department of Publicity, East Pittsburgh, Penn.

Warning Signals at Grade Crossings consisting of banjo signals tied into the main track circuit are being installed by the New York, New Haven & Hartford R.R. at numerous crossings in Connecticut. Following a recent wreck the State Public Utilities Commission ordered the removal of a number of these signals from the track signal system and they are now being utilized as highway warnings. While these are at present located at the track it is thought probable that in some locations, where specially dangerous conditions exist, they will be installed as distant warning signals.

Quebec Suspended-Span Hoisting Details Completed

By A. J. Meyers*

SYNOPSIS—Outline of program and details of equipment for floating to position and hoisting into place between cantilever arms the 640-ft. 5,000-ton suspended span of the Quebec Bridge.

The detailed arrangements for floating the great suspended span of the Quebec Bridge are now practically finished, and the completion of this task rests on favorable meteorological conditions. This span is 640 ft. long, 88 ft. wide and weighs, in floating-in condition, about 5,000 tons. It was erected at Sillery, about 3 mi. below the bridge site, over the shallow waters of Victoria Cove. During erection it was supported on staging under each panel point; afterward the intermediate supports were removed. As shown in Fig. 1, the suspended span, after it had been completely assembled and riveted up, rested on the end staging bents at L0 and L18. The scows for floating the span to the main bridge site, about 3 mi. up the river, were floated into the positions shown in the diagram under panel points L1, L2, L3, L15, L16 and L17, and as the tide lowered they came to a bearing on their concrete and timber beds. In the bottom of these scows, valves are provided which were opened and will be left open until the span is to be floated, so that the scows and the span will not be disturbed by the daily rise and fall of the tide.

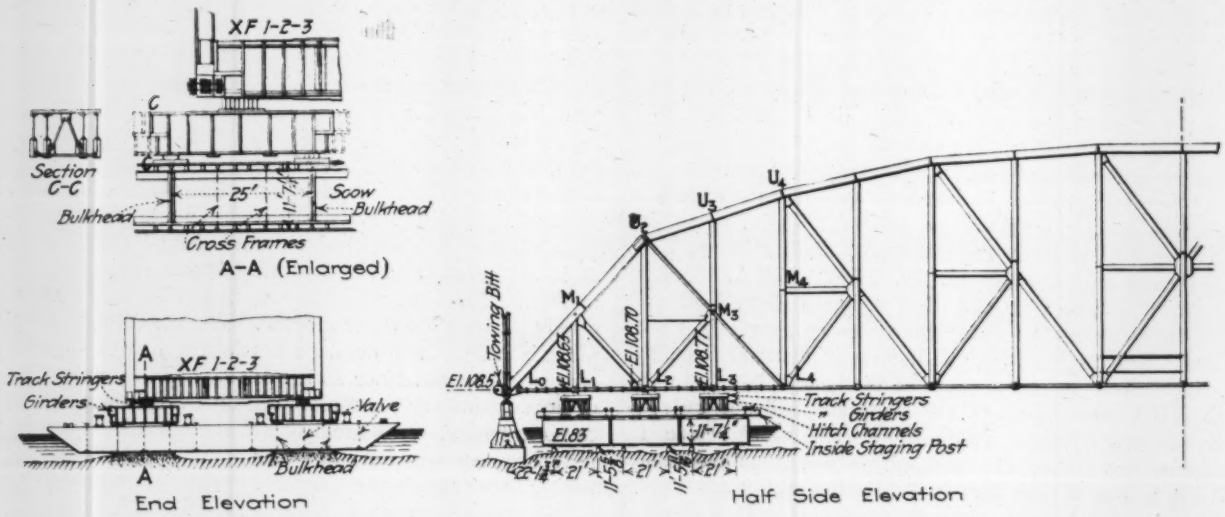


FIG. 1. ARRANGEMENTS FOR FLOATING THE SUSPENDED SPAN OF THE QUEBEC BRIDGE

Scows for Floating-In

The design of the scows was governed by the arrangement and requirements of loading and the possible condition of the surface of the river during floating-in operations; also so that they might have some commercial value after their work of floating-in the suspended span was completed. The average length from crest to crest of wave at the bridge site is about 40 ft.; the wave height is 4 ft. This unevenness of the surface of the river produces unequal upward pressures at the four corners of the span and consequent stresses in the sway and lateral bracing. The unequality of pressure is proportional to the horizontal cross-section of the loaded scows near the surface of the water. To reduce wave effect as much as possible, long, narrow scows with a deep draft would preferably be used. With the design of scow adopted the oscillation of the span from wave action produces only stresses in the sway and lateral bracing, which these systems are well able to resist.

The scows as built are 32 ft. 5½ in. wide, 164 ft. 6 in. long and 11 ft. 7½ in. draft over bilge timbers. Each has a steel frame made up of three longitudinal trusses, spaced 10 ft. 6 in. c. to c. and braced transversely by four water-tight steel bulkheads with intermediate cross-frames between the bulkheads, spaced 8 ft. 4 in. c. to c. No special longitudinal bracing in the horizontal planes is provided, as the 11½x5½-in. cross-timbers, spaced 2 ft. 9 in. c. to c., are bolted directly to the steel framework of the scow; and the 4-in. timber covering is spiked to these cross-timbers with 8x$\frac{7}{8}$-in. boat spikes, three at each intersection, providing an efficient resistance to any transverse or longitudinal horizontal-shearing and bending forces that may arise.

The load of the suspended span is transferred to the bulkheads by means of the cross-girders and I-beams shown in Fig. 1. The bulkheads transfer this load to the longitudinal trusses, which distribute it over the length of the scows.

In addition to the scows being designed to carry the load of the suspended span, in order that they may be used for freight-carrying purposes after their work of floating-in the span is completed, they are built to carry a load of 1,400 tons uniformly distributed over a length of 123 ft. and symmetrically placed about the transverse and

*Chief Draftsman, Board of Engineers, Quebec Bridge, Montreal, P. Q.

longitudinal center lines of the scows, or a load of 1,075 tons uniformly distributed over a length of 50 ft. at each end of the scow and symmetrically placed about its center lines. These two conditions of loading give the largest stresses in the web members of the three longitudinal trusses. The largest stresses in the chords of these trusses are caused by a loading of 280 tons uniformly distributed over a length of 50 ft. on either side of, but immediately adjacent to, the transverse center line of the scow, or a load of 180 tons uniformly distributed over a length of 50 ft. at the center of the scow and symmetrically placed about its center lines.

It was assumed that the weight of the scow itself produced no stresses in the longitudinal scow trusses and that the total superimposed load was carried equally by these three trusses. In calculating the maximum bending stresses in the chords of these trusses a coefficient of 0.75 was used to allow for continuity over the panel points. The allowable unit stresses provided for a safe unit stress in these trusses with the suspended span carried on four instead of six scows. The scows are placed under the suspended span and shimmed against the bottom flanges of the floor-beams. To make sure of favorable weather conditions while the span is floating, it should be lifted from its supports at L0 and L18 only immediately before its journey to the bridge site. In order to prevent the lifting of the span by the scows when the weather conditions are not favorable, there are a number of 8-in. disk bottom valves in each scow, and these are left open. The elevations of the beds of the scows were so chosen that the scows will be emptied through these bottom valves during the last low tide before beginning the journey to the site of the main span. The valves have a total area of one five-thousandth the clear area of the scows. All interior areas of the scows are given unobstructed access to some one of the valves, and it is estimated that the water will drain out practically as fast as the tide falls.

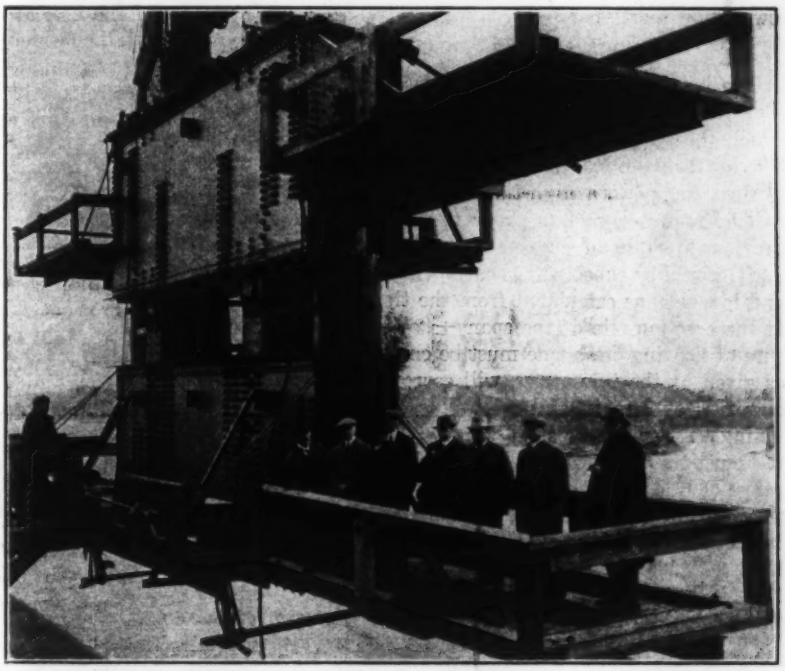


FIG. 2. UPPER AND LOWER JACKING GIRDERS FOR HOISTING QUEBEC SUSPENDED SPAN

The two 1,000-ton hydraulic jacks and operating platforms in place. On the platform—Messrs. Duggan, Mitchell, Porter, Johnson and Fortune, of the St. Lawrence Bridge Co.

Scow Loading

As illustrated in Fig. 1, the load of the suspended span is transferred from the floor-beams at each of the panel points L1, L2, L3, L15, L16 and L17 to the bulkheads of the scows by means of eight 24-in. 80-lb. I-beam track stringers, with their end-connection angles interlocked at the ends, and four track girders braced together by sway-bracing frames and top laterals. These I-beam stringers and track girders are part of the permanent floor material of the span—all the floor steel and the railway track floor, except the main floor-beams, being left off the span during the operation of floating-in and hoisting. (This floor material will be placed afterward by means of derrick cars.) The total load carried by one scow under these conditions is 970 tons, distributed over four bulkheads. The draft of the unloaded scow is 1 ft. 6 in., and when carrying the load of 970 tons the draft is 8 ft. 2 in.

The stresses in the truss members of the span while it is being supported entirely by the scows are such that a tension connection had to be provided at the joint U2; and the bottom-chord eye-bars between the panel points L0-L4 and L14-L18 had to be stiffened temporarily, as indicated in Fig. 1, with longitudinal timbers and transverse blocking and bolts. The subtension verticals and the subcompression diagonals directly over the scows had also to be specially designed and stiffened to take reversal of stress while floating the span.

The three scows at each end of the span are braced and connected together, as shown in Fig. 1, by using the inside staging posts from the falsework of the anchor arm as continuous connecting girders. Four of these posts are used for each set of three scows and are spaced 42 ft. c. to c. These posts were connected to the scows by means of a pair of cross-channels, pin-connected to vertical angles which were in turn bolted to the transverse bracing frames of the scows. Wedges were driven between the posts and the scow decks. These connections and the connecting girders were calculated to resist the bending and shearing stresses arising from the action of a 4-ft. wave.

Just before the span is lifted off the supports at L0 and L18 the load is nearly all taken by the scows, and the span could be easily displaced from its position by the current and wind, unless it is anchored against their combined effect. It is desirable to prevent this shifting off before the actual moment of starting arrives, inasmuch as it may happen that after deciding to raise the span preparatory to moving out, a change in the weather conditions may make it desirable not to proceed on the journey and the span would have to be returned again to its bearings on the staging bents, to await the next favorable opportunity for making a trial.

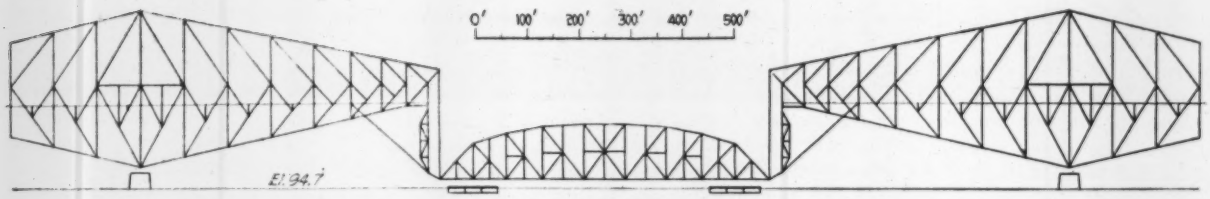


FIG. 3. GENERAL SCHEME FOR HOISTING THE QUEBEC BRIDGE SUSPENDED SPAN

To keep the span in its position until the final decision to float away has been made, timber bents will be placed between the points L0 and L18 and the adjacent scows and also bents on the shore side of the span, against which the scows will guide themselves as the span is raised or lowered on its supports.

Weather and Tide

The bottoms of the scows are placed at El. 83, where they rest on bearing timbers. The bed of the river over which the scows must pass will be cleared off to El. 82. The draft of the loaded scows will be 8 ft. 2 in. In order to float the span, a high-tide elevation of at least 92 ft. will be required, and in order to drain the scows at the previous low tide an elevation of low tide of not more than 82 ft. would be expected.[1] Inasmuch as elevations of high and low tide, as calculated from the tide tables, may vary at the erection site of the span ± 2½ ft., in order to be sure of floating off, a tide must be chosen whose elevation, as given by the tide tables, will correspond to a high-tide elevation of 94.5 ft. and a low-tide elevation of 79.5 ft., giving a range of tide of 15 ft.

Four or five days in succession, when the elevations and range of tide would be suitable for draining the scows and floating the span, occur at intervals of about two weeks' time. The first favorable tide period, after the preparations for floating the span are complete, is about Sept. 12. If the weather conditions are not favorable during this period, it will be necessary to await the next favorable height and range of tide, and so on until suitable tide and weather conditions coexist.

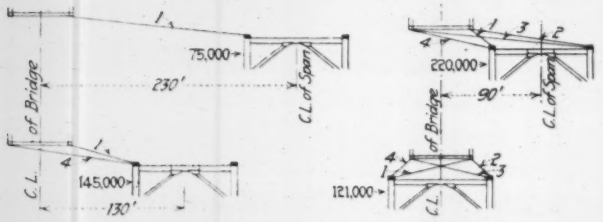


FIG. 4. LINES FROM CENTER SPAN TO MOORING TRUSSES

A full daily statement of the meteorological conditions throughout the country giving the position of high- and low-pressure centers at 8 a.m. and 8 p.m. will be received from the Canadian Meteorological Service at Toronto. These statements will be telephoned at about 11 a.m. and 11 p.m. respectively, with a prediction of the possible wind velocity. By barometric observations at the bridge site it can be estimated whether any threatening centers of low pressure, indicating strong winds, at a great distance on the previous day, have moved more quickly or slowly than was expected. The appearance of the sky, the velocity and direction of the wind just before starting and the indications on an electric storm detector will also be well considered before deciding whether or not to start. It is estimated that any winds which will exert a greater pressure than 2 lb. per sq.ft. can be foreseen, and in that event no start will be made. The current velocity at the bridge site is a maximum, one hour before high tide, and is flowing westward at a rate of 6.3 to 7.3 mi. per hr. in a direction which will carry the span toward the main bridge site. At high tide the current velocity is less by about 1 mi. per hr. The change of current from a westward to an eastward direction, when the velocity is zero, occurs about 1 hr. after the time of high tide.

Towing the Span

The span on its journey to the bridge site will be towed and controlled by tugs, assisted by the westward current and influenced by the coexisting wind of unknown direction, but exerting a force of not more than 2 lb. per sq.ft. With tugs having a pulling capacity of 100,000 lb. in a 4-mi. current, a velocity of the span of 4 mi. per hr. can be produced relative to the water, and at the same time overcome the effect of a 2-lb. wind on the span.

About 50 min. before high tide the span will be floated away from its erection site, with a westward current having a velocity of about 6 mi. per hr. At first the tugs will be used mainly for guiding the span. While on its journey to the bridge site the rate of progress will be observed by means of a series of ranges placed 0.2 mi. apart within 1 mi. of the bridge and ½ mi. apart from 1 to 3 mi. distant from the bridge. The span should arrive at the bridge with a velocity of current of about 4 mi. per hr. With such a current and a wind velocity of not more than 2 mi. per hr. the tugs will have no difficulty in stopping the span before coupling up to the mooring trusses.

The time of arrival will be controlled by the tugs so that the span will be in position about half an hour after high tide, when, for a period of 1 hr., the current does not exceed 3 mi. per hr. and during which it changes direction. The tugs will hold the span against the wind and current while the 1¼-in. steel mooring lines are being connected, as shown in Figs. 4 and 5. The span will then be pulled directly under its final position in the bridge by means of these 1¼-in. mooring ropes, eight in number, two connecting at each corner of the span. At the end of each rope is a loop which, as soon as the span has come within reach and the speed is controlled, will be thrown over a double-headed cast-steel snubbing block or towing bitt, bolted to a seat provided at the joint XLO of the suspended span. Each 1¼-in. rope is calculated to take a pull of 75,000 lb. The ropes pass through sheaves at

[1] In order to obtain the relation between the Quebec elevations of tide, as given in the Dominion Naval Service tables, to the elevations used at the bridge site, it is necessary to add to the high-tide elevations 80 ft., and to the low-tide elevations 79.25 ft. Observations, extending over a considerable time, have shown that the deviation from the elevation for the bridge site of high tide will amount to a maximum of ±2 ft. for high tide and for low tide ±2.05 ft. At the erection site of the suspended span the deviation from the elevation as calculated from the tide tables is ±2½ ft. for high and low tides.

the lower corners of the mooring trusses and from there run vertically to the trusses, where they connect to a nine-part ¾-in. wire-rope tackle, which leads back to the drums of the derrick hoists, situated on the floor at the ends of each cantilever arm.

With one line out on each end, the load for a 7-mi. current and 1-lb. wind (77,500) would be carried. With two lines cut (second position, Fig. 4) the upstream pull of 145,000 lb. would provide for a 7-mi. current and a 6-lb. wind (145,000 lb.). With all four out at each end, a 220,000-lb. force could be exerted to overcome a 7-mi. current plus an 11½-mi. wind (219,000 lb.). In final hoisting position the upstream force becomes 121,000 lb., which is good for a 7-mi. current and a 4-lb. wind. By transferring line 1 to bitt 2 in the third position a 7-mi. current and a 17-lb. wind (293,000 lb.) would be overcome; by transferring line 4 to bitt 2 in the final position a 7-mi. current and a 9-lb. wind (186,000 lb.) could be provided for.

The mooring frames, as shown in Figs. 3 and 5, are made of two steel trusses with bracing and are suspended from the cantilever-arm floor-beams at panel point CF1. They are hung at the upper ends so that they can be swung back, in order not to obstruct the channel unnecessarily, practically up against the plane of the bottom chords of the cantilever arms, by means of a nine-part ⅞-in. wire-rope tackle leading from the lower corners of the trusses to the connection to the floor between panel points CF5 and CF6 of the cantilever arms and from there to the main hoists, situated at the floor level of the cantilever arms and on the center line of the bridge. These trusses and their connections throughout were designed to take a transverse pull from the suspended span of 300,000 lb.

Work of Hoisting

As soon as the span is pulled into position, before being lifted from the scows, the hanger chains will be swung down and connected through the slotted holes at the lower end to the pins at the top of the short hanger link, shown in Fig. 6, connecting to the supporting girders under the joint XLO.

These hanger chains at each corner of the span are made up of four strings of slabs to each chain. Each slab is built up of two 30x1⅛-in. carbon-steel plates. The allowable working erection unit stress through the pin holes was 20,000 lb. per sq.in., which included the stress from 20% of the lifted load as impact. No reinforcing pin plates were used around the pin holes, and special tests made showed that this apparently high working stress

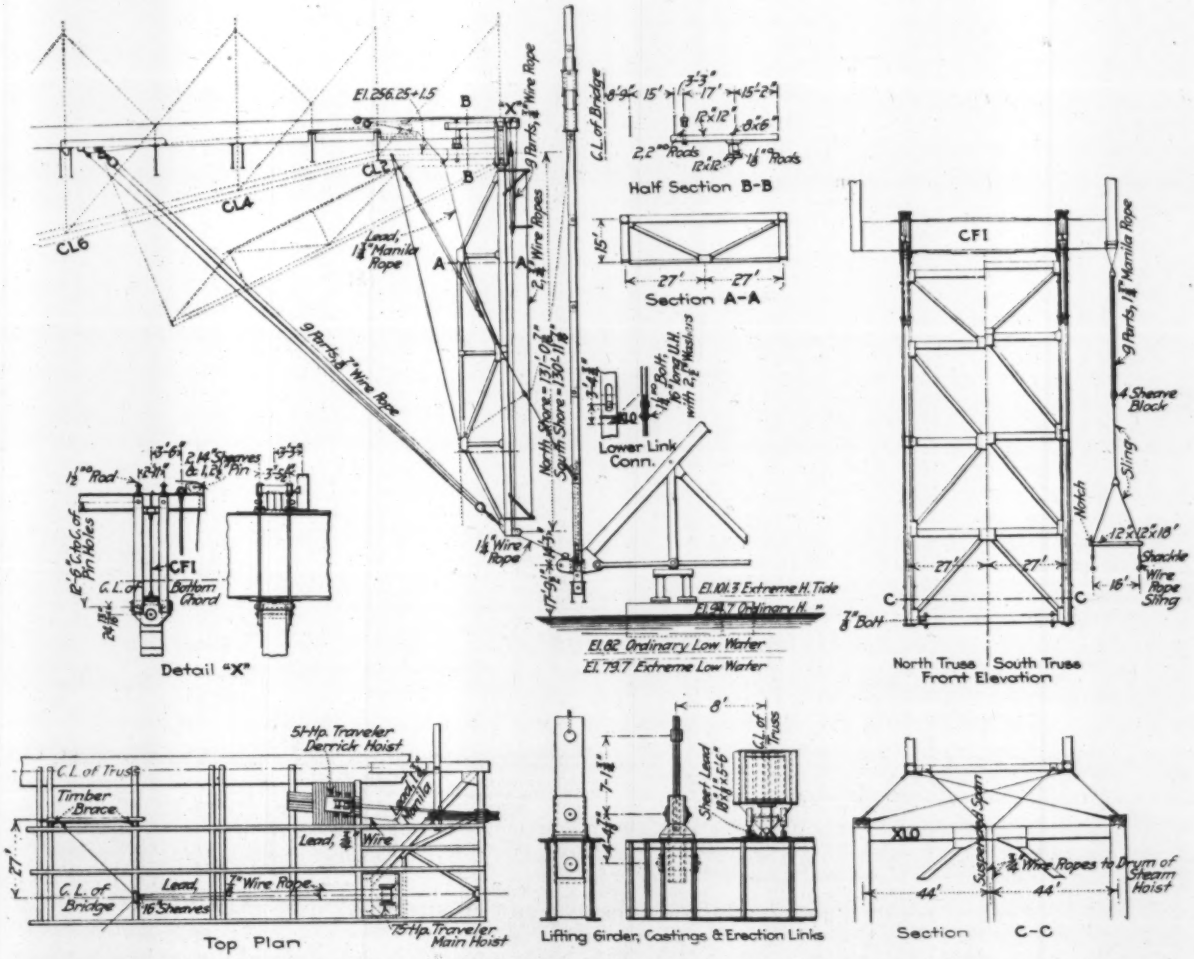


FIG. 5. DETAIL OF ARRANGEMENTS FOR MOORING AND HOISTING THE SUSPENDED SPAN OF THE QUEBEC BRIDGE

through the pin holes was perfectly safe for this type of connection. The slabs were manufactured and shipped in lengths of about 30 ft. c. to c. of end pin holes. They were controlled after being suspended from the jacking girders by means of a two-part tackle connecting to the cantilever-arm trusses at panel point CL2.

The hanger chains connect at the lower end to supporting girders, shown in Fig. 6. These supporting girders are 6 ft. 11½ in. back to back of angles and 25 ft. long. They are built up of two plate girders, connected together by bearing, stiffening and pin connection diaphragms and also by cover-plates. The load of the suspended span is transmitted to the girders by means of a cast-steel rocker joint, designed to allow turning about the transverse and longitudinal axes of the bearing.

The upper supporting girders at the CUO joint of the cantilever arm are designed in a similar manner to the lower supporting girders, the rocker bearing for the girders and the pin connection for the vertical hangers allowing turning about both the transverse and longitudinal axes of the supporting girders. With bearings of this design the suspended span may move in any direction under the influence of whatever external forces from wind or current may act on it during the hoisting of the span.

The total load carried by the hanger chains while lifting the span is 5,147 tons. The supporting girders, hanger chains, jacks and jacking girders and all their connections are designed throughout to carry this lifted load plus 20% impact.

As shown in Fig. 6, the jacking girders are located at the same elevation as the floor of the cantilever arm. They are hung from the upper supporting girders by stiff hangers that are pin-connected at the upper and lower ends. At the lower ends these stiff hangers are attached to guides built of plates and angles that pass through the upper jacking girders and are riveted into the lower jacking girders. The position of the lower girders is therefore fixed, and their distance from the panel point CUO does not change during the jacking operation. The upper girders are the movable girders, and they slide up and down the guides as the 1,000-ton jacks are operated. These jacks are placed between the upper and lower jacking girders, two at each corner of the span, and do the work of lifting the span. In order to avoid binding of the jacks, due to the deflection of the jacking girders under load, the jacks are provided with rocker seats at their upper and lower bearings. They are located at the extreme ends of the jacking girders, where they bear

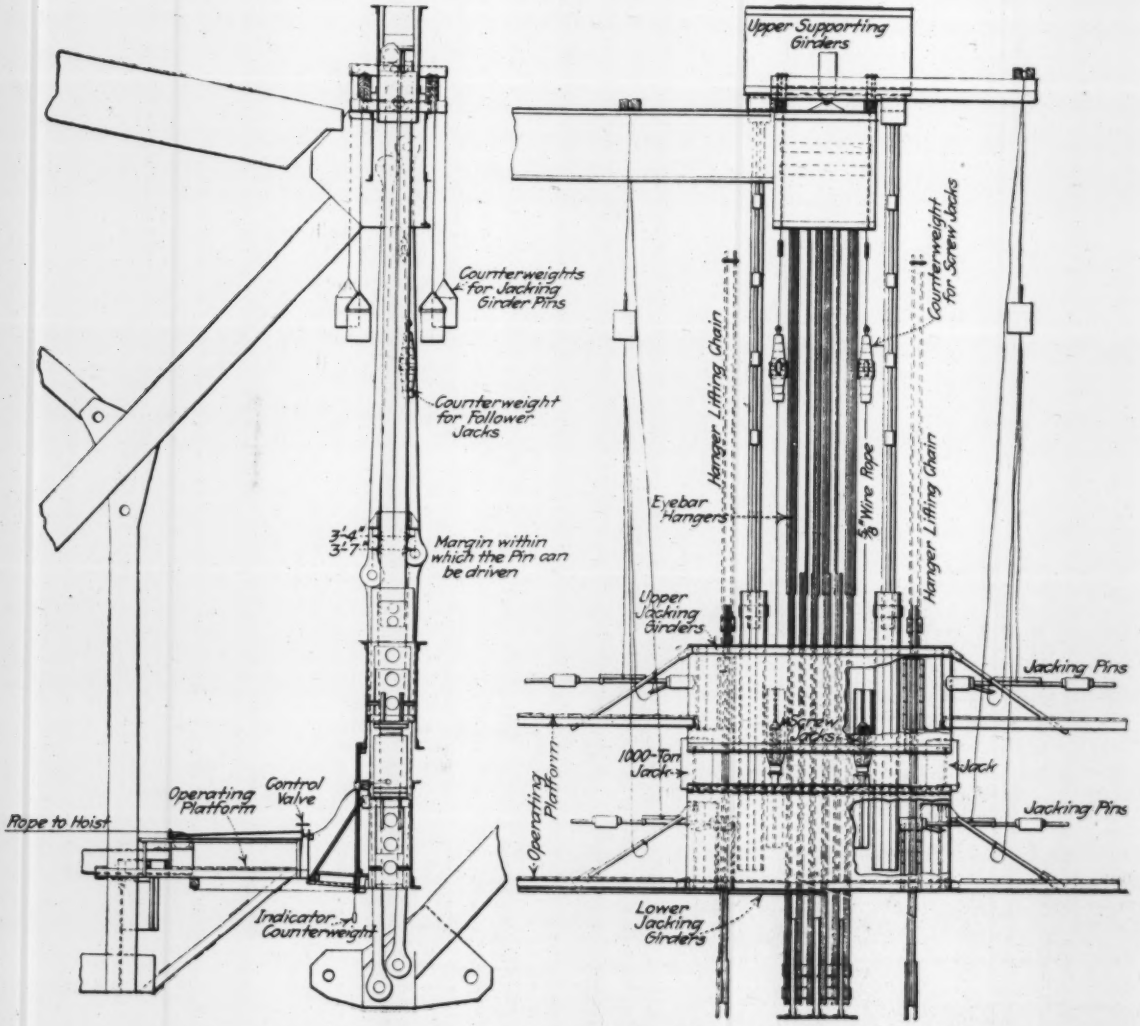


FIG. 6. JACKING EQUIPMENT FOR HOISTING THE QUEBEC SUSPENDED SPAN

against transverse diaphragms riveted into the jacking girders.

In addition to the hydraulic jacks, following-up screw jacks are provided as a safety device in case anything should go wrong with the pumping system for the hydraulic jacks or the jacks themselves, so that they should fail to maintain the pressure of about 4,500 lb. per sq.in. necessary to hold the weight of the suspended span while being lifted. These screw jacks also react against cross-girder diaphragms in the jacking girders. The screw itself is counterweighted so that practically all the friction due to its own weight is eliminated, and the operator of the screw jacks will be able to turn the screw without difficulty and follow the operations of the hydraulic jacks with equal speed and very little exertion.

The hanger lifting chains are guided between cross pin-bearing diaphragms riveted into the jacking girders. These chains are bored every 6 ft. c. to c. to receive a 12-in. pin while the cross-diaphragms have holes for the same diameter of pin bored at 2-ft. centers. The clearance provided in the pin holes of the hanger chains is ½ in. transversely and ⅞ in. longitudinally, and in the pin holes of the cross-diaphragms 1 in. transversely and 1¾ in. longitudinally. This clearance is considered ample to allow the pins to be driven, no matter what position the span may take while hoisting, due to the action of current and wind. Having the pin holes in the cross-diaphragms at 2-ft. centers enabled the pin holes in the hangers to be bored at 6-ft. centers and at the same time accommodated the 2-ft. stroke of the jacks.

Each operation of the jacks will lift the span 2 ft. During the lifting or upward stroke, the 12-in. pins engage the hanger chains through the diaphragms in the upper jacking girders. At the finish of the stroke the pins are entered in the diaphragms of the lower jacking girders to engage the hanger chains. The upper pins are then removed, the jacks and upper girders lowered, the upper pins again entered, the lower pins removed and the jacks again operated. As each 30-ft. length of hanger chain passes up through the upper jacking girders it is disconnected and removed. The jacking pins are counterweighted and balanced to enable them to be handled with facility by the men on the operating platform.

The jacks are supplied with water under pressure of about 4,500 lb. per sq.in. by a pair of direct-acting double-plunger pumps, operated by compressed air and located on the center line of the bridge floor at the ends of the cantilever arm. By means of a pair of control valves installed in front of the pumps the supply of water sent to each corner of the span can be regulated, and in this manner with the aid of a simple counterweighted-line indicator in front of the valve operator, which will show any difference in level between the lifting girders on each side of the bridge, the two corners of each end of the span can be kept at the same elevation. Another set of valves with a similar indicator is placed on the operating platform in front of each set of jacking girders to control the water-supply to each separate jack, so that the ends of the jacking girders, during jacking operations, can be kept level. The feed-pipe line is connected to the jacks by means of two ⅜-in. copper pipes which are sufficiently flexible to allow for any swaying motion of the span while being hoisted.

Tests of the complete water-feed pipe lines and hydraulic jacks were made under a pressure of 6,000 lb. per sq.in. The jacking girders were tested with a load on the jacks equal to 5,000 lb. per sq.in. pressure. The working load on these jacks would be about 4,500 lb. per sq.in. Each individual scow was tested for leakage after the scows were in place, by closing the bottom valves of one scow at a time and allowing it to react against the weight of the span as the tide rose.

The vertical distance through which the span will be hoisted depends upon the varying elevation of the water level, but will be approximately 145 ft. Each operation of the jacks hoists the span 2 ft., and a cycle will take about 15 min. to complete. Altogether there will be approximately 73 separate lifting operations, and the time consumed from the moment of coupling up to the hanger lifting chains to the moment of driving the last pins connecting the two portions of the permanent eye-bar suspenders will be approximately 20 hr., provided no unforeseen delays occur.

The work is being carried out under the supervision of the Board of Engineers, Quebec Bridge, composed of C. N. Monsarrat (Chairman and Chief Engineer), Ralph Modjeski and H. P. Borden. The St. Lawrence Bridge Co. is the contractor for the superstructure, of which company Phelps Johnson is President; G. H. Duggan, Chief Engineer; George F. Porter, Engineer of Construction; S. P. Mitchell, Consulting Engineer of Erection; and W. B. Fortune, Erection Superintendent.

Enlarging the Engineering Societies' Building

The August *Proceedings* of the American Society of Civil Engineers contains the final agreement between the governing board of that society and the United Engineering Society, under which the former becomes one of the founder societies and acquires the ownership of a one-fourth interest in the Engineering Societies' Building at 29 West 39th St., New York City, with the ground on which it stands.

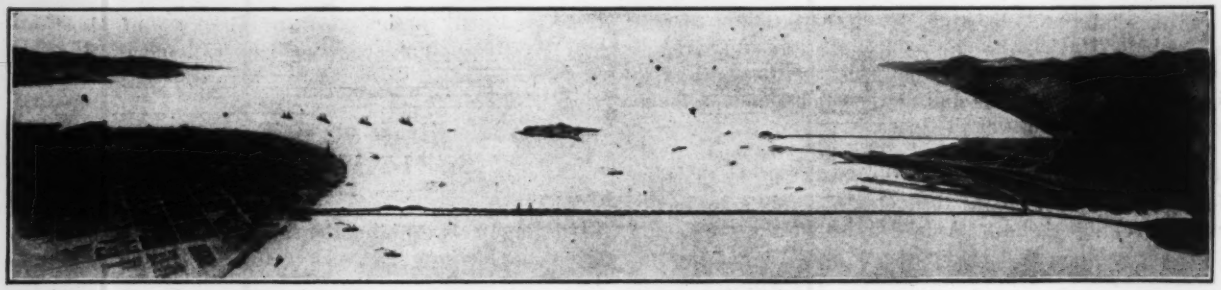
The building is to be enlarged by the addition of three more stories, making a total height of 15 stories. The building committee in charge of this work is made up of one member from each of the constituent societies, Messrs. H. H. Barnes, Jr., H. G. Stott, Charles Warren Hunt and Charles F. Rand. The committee has awarded the contract for the preliminary structural work, and the contractor began work on Aug. 1.

The American Society of Civil Engineers is to pay the cost of adding these three additional stories, provided the cost is not in excess of $250,000, in which case the balance will be paid by the United Engineering Society. The library now owned by the American Society of Civil Engineers is to be added to the Engineering Societies' library, the whole to be conducted as one public library under the management of the United Engineering Society. The representatives of the American Society of Civil Engineers in the United Engineering Society are Clemens Herschel, Charles Warren Hunt and J. V. Davies. Suitable changes have been made in the constitution and bylaws of the United Engineering Society so that the four societies stand on an equal footing in it, exactly as would have been the case had the American Society of Civil Engineers joined the other three societies in the building enterprise twelve years ago.

Planning for a Bridge Across San Francisco Bay

All traffic, both freight and passenger, entering San Francisco from the east has to be transferred across San Francisco Bay, a body of water nearly five miles in width. The cities of Oakland, Alameda, and Berkeley, situated on the east side of the bay, contain the residences of many thousands who work in San Francisco. The steady growth of traffic across the bay has caused the agitation of plans for constructing bridges or tunnels to give direct passage across the bay. On account of possible interference with navigation, the construction of such a bridge requires the approval of the War Department.

A public hearing was held at San Francisco Aug. 15 and 16 and in Oakland on Aug. 17 by a Board of Engineers made up of Col. Thomas H. Rees of San Francisco, Col. Charles L. Porter of Portland, and Major George B. Pillsbury of Los Angeles. Three plans for bridging the bay were presented. The first was offered by a firm known as the Associated Bridge Engineers, composed of Wilbur J. Watson & Co. of Cleveland, Wm. Russell Davis of Albany, and Harlan D. Miller of Albany, N. Y., and Oakland, Calif. A photograph of the design submitted is reproduced herewith. These engineers propose to cross the bay at a point farther south than the bridge sites hitherto considered. Practically all the piers on the San Francisco water front used by ocean shipping are located north of the line of the bridge so that the interference with navigation would be a minimum. The bridge is therefore placed at a comparatively low level, the vertical clearance above mean high water being 20 to 90 ft. Near the San Francisco shore there are two 575 ft. spans with a vertical clearance of 115 ft. To admit the passage of occasional vessels which might require even a greater height, a drawspan is located about one mile from the San Francisco shore having a length of 250 ft. This could be of either the bascule or the direct-lift type, and in the latter case a clear height of 200 ft. would be afforded. A similar provision would be made for the benefit of navigation where the bridge crosses the Oakland channel. The span here would have a vertical clearance of at least 60 ft. above high water when the bridge was closed and at least 200 ft. with the bridge open.



"ASSOCIATED BRIDGE ENGINEERS'" BRIDGE ACROSS SAN FRANCISCO BAY

The total length of the structure would be approximately 30,200 ft., of which 17,400 ft. would be of steel spans. There would be sixty steel spans 250 ft. long and twenty-three 100 to 200 ft. long. As designed, the bridge would have a double deck, the upper one carrying two roadways for slow moving vehicles and a double-track roadway for high speed automobiles. The lower deck would carry two railway tracks for overland trains and two railroad tracks for interurban trains.

On the eastern side of the bay the water is very shallow for a long distance out from the shore. The present terminals on the eastern side of the bay for the ferries running to San Francisco are located between one and two miles out from the mainland, being carried partly by a fill and party by pile trestles across the mud flats and shallow water. The Associated Bridge Engineers base their estimates for the bridge on pier foundations made by driving piles, cutting them off below the clay line so that they would be in no danger from the teredo, sinking interlocking cellular caissons of reinforced concrete upon the cluster of piles and filling the chambers of the caissons with concrete deposited through a tremie. Where the spans are placed high above the water this construction would be varied by constructing steel towers on piers carried 10 ft. or more above high water.

The estimated cost of construction of the bridge is $18,700,000, and the estimated cost of land damages, interest during construction, engineering and incidentals is $5,200,000 making a total of $23,900,000.

The plan for financing the Associated Bridge Engineers' project is to organize a bridge assessment district, made up of San Francisco and the cities on the western side of the bay which would assume responsibility for the cost of construction. It is estimated that by charging a toll of 2½c. per passenger and suitable rates for trains, automobiles, etc., the bridge would earn an annual revenue sufficient to meet operating expenses, maintenance, interest and sinking fund charges.

Plans for a long span cantilever bridge were presented by Charles E. Fowler of Seattle. The site on which he proposed a bridge is from Telegraph Hill in San Francisco to Goat Island, and thence to Oakland. He proposed a clear height of 150 ft. and steel spans of a total length of 2,950 ft., with one cantilever span 800 ft. long. The estimate of cost was $75,000,000. Mr. Fowler proposed that a corporation be organized to build the bridge and operate trains over it in connection with the operation of the street railways on the east side of the bay. Plans for a suspension bridge with 2,000 ft. span, and a height of 180 ft., were presented by Alan C. Rush. The estimate of cost was $32,000,000.

On the following day plans for tunnels under the bay were presented by Taggart Aston, Jerome Newman, John G. Little, and Carl F. Reuter. A serious objection to the tunnel plan is that a tunnel would not be satisfactory for automobile traffic across the bay, which is very heavy, constantly increasing, and which will stand a high rate of toll and therefore be very profitable for a bridge.

News of the Engineering World

New Providence Water-Supply to be Filtered

Plans for filtering the new water-supply of Providence, R. I., prepared by Frank E. Winsor, Chief Engineer, were adopted by the Providence Water Supply Board on Aug. 23. The question has been under consideration for some time whether the water-supply should be filtered at the outset, or whether the site of the new Scituate reservoir should be stripped of surface soil before it is filled. Reports on the matter have been submitted by the consulting engineers, Allen Hazen, F. P. Stearns, and Samuel M. Gray.

Chief Engineer Winsor in his report to the board stated that "while it might be possible to obtain water of fairly satisfactory quality from the Scituate reservoir without filtration, he was strongly of the opinion that it should be the aim to procure the best water reasonably obtainable and that this cannot be secured in any other way than by efficient filtration." The reservoirs in which the water is stored after filtration will be covered to exclude the light and prevent the growth of algæ.

Concerning the proposal to strip the bed of the reservoir of surface soil, Mr. Winsor stated that the cost of stripping the bed of the entire reservoir has been estimated at not less than $700,000, and might very likely be a considerably larger sum. In his opinion the advantage to the quality of the water to be gained from stripping the reservoir would not be sufficient to justify such an expenditure, since after a period of uncertain duration the water conditions in an unstripped reservoir become the same as if the reservoir had been stripped. He recommended therefore that the area stripped should be confined to that necessary to obtain a proper amount of impervious material for use in building the dam. Such area may be from 10 to 25% of the total area of the reservoir. The height of flow line of the new reservoir has been fixed at El. 284.

Disposal of Packing-House and Stockyards Refuse

The disposal of packing-house wastes and stockyards sewage at Chicago has become a serious problem, owing to the enormous amount of such material and the large proportion of water required for the dilution of this special class of refuse as now discharged into the Drainage Canal. Experiments have been conducted, including screening and the activated-sludge process, and some definite action is soon to be taken. At a recent conference between the packers and the Sanitary District of Chicago a commission was appointed, consisting of W. D. Richardson, chief chemist of Swift & Co., and Langdon Pearse, of the engineering department of the Sanitary District. They were instructed to determine whether the wastes originating in the stockyards and packing houses can be practically treated by the activated-sludge process, at one plant or a community plant, so as to produce an effluent proper to be discharged into the channels of the Sanitary District. If their conclusion is affirmative, they are to report what works and appliances are necessary for collecting and treating the wastes; where these works should be located; and what will be the approximate cost for installation, operation, maintenance and repair of such a plant.

Montreal Aqueduct Combined Bridge and Headgates

Three large Stoney gates and a highway bridge combined in one structure form Contract 3 of the Aqueduct Enlargement of the Montreal Water-Works, for which bids are to be opened on Sept. 6. Each of the Stoney gates will be 58½ ft. long by 18 ft. high, overall, and will have a lift of 17 ft. under a 23-ft. head. They will be made up of five horizontal girders and two vertical end girders, properly braced, and a ⅜-in. steel skin plate on the water side. Each gate will have a clear waterway of 57 ft. between the bridge piers and abutments and the latter will be carried up as towers to house the lifting mechanism of the bridge. The jackshafts will be inclosed in horizontal members of the combined structure.

The bridge will be 251 long, including abutments, and will have a roadway 36 ft. wide (designed for street-railway tracks ultimately) and two 5-ft. sidewalks. The combined structure, except for the gates, will be of reinforced concrete.

The detailed plans for the headgates were made by the Dominion Bridge Co. and of the bridge by L. G. Mouchel and Partners, both of Montreal. Frederick E. Field is resident engineer and Frank Dorrance is assistant engineer of the filtration and aqueduct works, and T. W. Lesage is engineer and superintendent of the Montreal water-works.

War Department Hearing on Allegheny Bridge Raising

The latest development in the long-standing controversy over the raising of the Allegheny River bridges in Pittsburgh is the report of Gen. William M. Black, Chief of Engineers, to the Secretary of War, concurring in new recommendations made by Lieut.-Col. Francis R. Shunk. These recommendations reduce the final clearance under the bridges by 4 ft., thereby reducing the approach grades. They also allow the changes to be made at the rate of one bridge every two years, until 1929. On receipt of Gen. Black's report Secretary of War Baker set Aug. 31 for a hearing at Washington on this report.

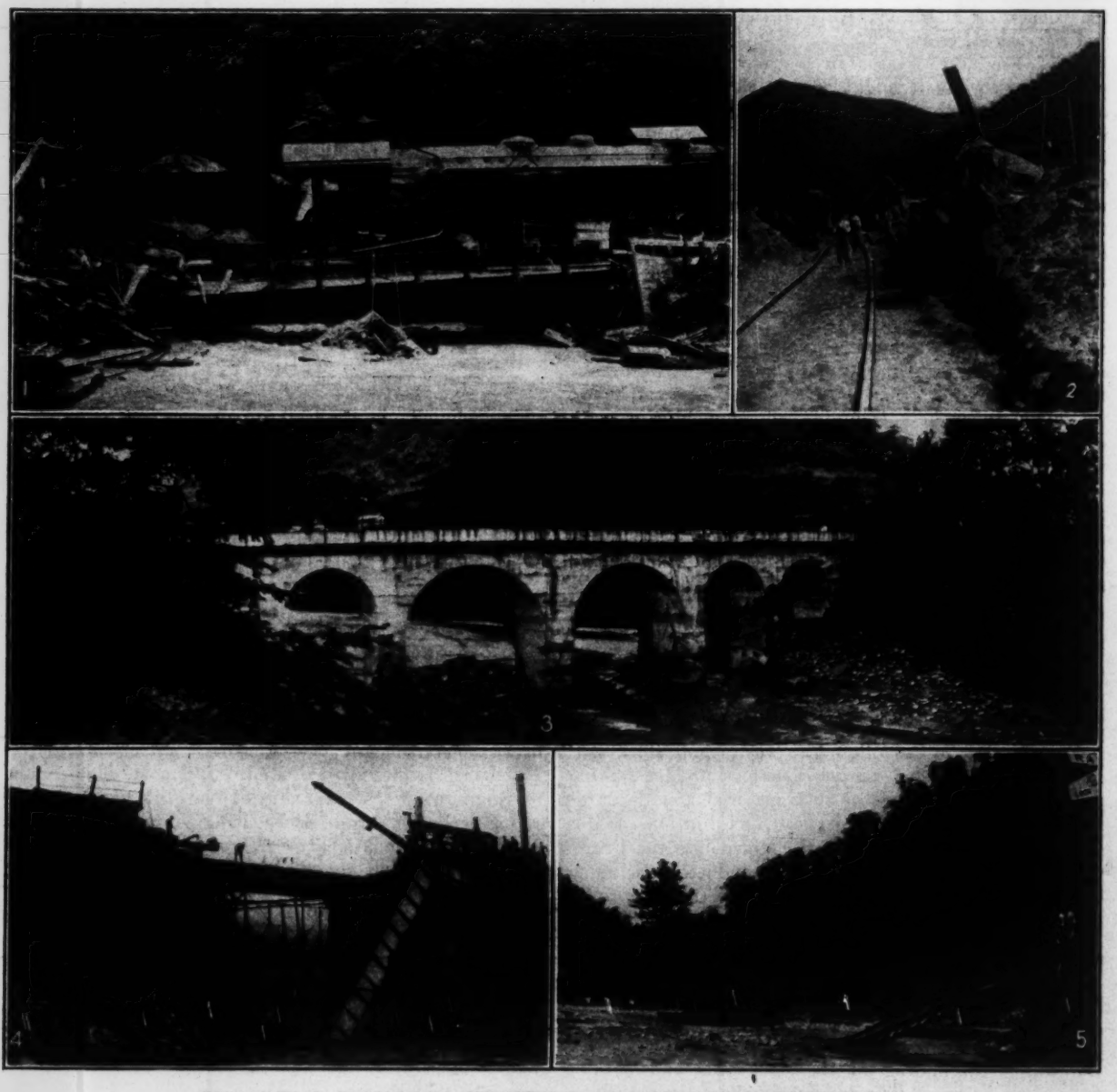
The city authorities of Pittsburgh and the Allegheny County officials are unanimously opposed to the order, which would mean the rebuilding of the six publicly owned structures. It was their contention during the hearings that the bridges, which are many of them main arteries of traffic, could not be reconstructed with the 5%

grades needed by the clearance originally suggested by the U. S. Engineers, and that the damages consequent to moderate grade approaches in the Pittsburgh downtown district would add several millions to the cost of reconstruction of the crossings themselves. The War Department does not agree with this, and in his report Lieut.-Col. Shunk stated:

> It is my opinion that the alleged cost of $13,752,049 simmers down to the following: The county will be required to spend $2,814,717 (which I think a liberal estimate), for which it will get full value in new bridges, and will be out of pocket a sum not to exceed $1,091,559, which is already paid. To offset this, improved navigation on the Allegheny River will be a benefit.
>
> To sum up, it is my opinion that these bridges are obstructive to navigation; that the improvement of the Allegheny will be nullified unless they are modified, and that the advantages which will result from the modifications will outweigh the disadvantages. I therefore recommend that the necessary modifications be ordered by the Secretary of War. In consideration of the expense entailed upon the county it seems just to give them plenty of time to do the work.

West Virginia Flood Damage

It is now very doubtful if any complete meteorological data will be obtained from the Aug. 9 floods in the Coal River, Cabin Creek and Paint Creek watersheds in West Virginia, notes on which have appeared in the last few issues of *Engineering News*. It has been established that there were no rain gages in the district, and so far no determinations have been made of the discharge of any of the three streams, so that it is impossible to state accurately the rainfall and runoff. All manner of estimates as to the amount of rain have been given, but none of them are at all reliable except possibly one that was taken by a retired mine fireboss at Kayford, who claims that he measured the rainfall in an ice cream freezer and that in three and a half hours 5.8 in. fell. While the water was higher on Coal River, property damage was less as it is less thickly settled.



FIGS. 1 TO 5. DAMAGE TO STRUCTURES IN FLOODS IN WEST VIRGINIA

Fig. 1—Heavy locomotive holding short bridge in place. Fig. 2—Cut through débris in railway yard. Fig. 3—Concrete bridge which withstood flood. Fig. 4—Steel bridge which failed. Fig. 5—Typical railway washout

The estimates of the damage are still somewhat inaccurate, but it appears now that 520 houses were washed out and destroyed on Cabin Creek alone. The damage to railroad property, including rights of way, rolling stock, etc., will probably be not less than $500,000. The county roads on both Coal River and Cabin Creek have been entirely washed out, and a considerable amount of money must be expended to build new roads. Some of the mining towns are so completely destroyed that the coal companies may stop running entirely. The majority of the towns, however, will be rebuilt and the mines put in operation again as rapidly as possible. Labor will be scarce as there has been a general exodus from the creek on account of the flood. It is estimated that there is less than one-third the normal population on Cabin Creek at the present time.

The flood damage to bridges and railway embankments was almost complete. The accompanying views show some of the conditions after the flood. The reinforced-concrete bridge in the view is only 300 ft. upstream from the Chesapeake & Ohio Ry. bridge destroyed as shown in Fig. 4. The concrete bridge, however, stood intact although it had to take the full head of the flood. The washout of railway embankments is well illustrated in Fig. 5. There are miles of railway track taken out in this manner. In many places the creek has shifted its bed 100 yd., leaving the bridges high and dry. Fig. 1 shows a large Mallet compound engine which was on a bridge at Cane Fork to prevent the bridge from being washed out and to deflect the water away from the machine shops there. The shops were saved by this method as the river broke through and formed a new channel and great damage was caused to the town of Eskdale by the extremely high water thus occasioned. The railway yards at Cane Fork were covered 5 or 6 ft. deep with the débris from the flood and the tracks had to be excavated as shown in the view in Fig. 2.

The State Department of Health, under the direction of Mayo Tolman, Director of the Division of Sanitary Engineering, was very active in sanitary regulation of the district after the flood. Immediate steps were taken to prevent the outbreak of typhoid fever from polluted water and all wells were disinfected as soon as possible and posted with a sign "This well probably safe for drinking." Anti-typhoid vaccine was furnished free to doctors in the flood district and it is estimated that nearly 5,000 persons received the treatment. Several carloads of lime were shipped into the district so the people could have all they desired for sprinkling about their homes. Coal companies were very quick to appreciate the coöperation of the state and did everything in their power to alleviate the suffering among the miners' families.

Another Cantilever Bridge for the Mississippi

The latest addition to the bridges spanning the Mississippi River will be a cantilever bridge at Burlington, Iowa. There is a low-level railway bridge at that point, but the new bridge will be for highway traffic, and will have its channel span at such a height as to give 56 to 57½ ft. clearance above high water. This will allow for navigation and thus avoid the necessity of a draw span. The approaches will have 4% grades. The main part of the bridge consists of cantilever trusses giving a channel span of 480 ft. c. to c. of piers, and two shore spans of 260 ft., or a total length of 1,000 ft. over the trusses. The central suspended span is to be 216 ft. long, carried by 132-ft. anchor arms. At the west (Burlington) end, there will be eight deck I-beam and plate girder approach spans on steel bents, and a 140-ft. deck-truss span to the shore arm of the cantilever. At the east end there will be six plate-girder spans and four truss spans of 120 to 175 ft.; all these will be deck spans on cylinder piers.

The total length of steelwork will be 2,463 ft., with a masonry abutment and short fill at the west end, and a short fill at the east end to connect with a river-front levee on which a highway is located. The foundations of the main piers are of concrete, on piles driven into hardpan. The bridge connects the city with a county road, and tolls will be charged. The project is being financed jointly by the city and the Commercial Club, the latter's interests to be bought out eventually by the city. There will be a 21-ft. roadway and a single 5-ft. sidewalk, and provision is made in the floor system for a future track for an electric railway. The bridge was designed and is being built by the Wisconsin Bridge & Iron Co., of Milwaukee, Wis. Work is now in progress on the substructure and the approaches.

The Boston Dry Dock Coffer-Dam, which failed some weeks ago, as noted in "Engineering News," is to be reported on by Joseph Ripley and Mortimer G. Barnes, Consulting Engineers, of Albany, N. Y.

A New Union Station at Jacksonville, Fla., is to be started soon. The Jacksonville Terminal Co. under an arrangement just completed will erect a station which will cost with the trackage change necessary for its erection about $3,000,000. Definite plans for the station are still under discussion.

Damage to Roads and Bridges in the recent floods in North Carolina is estimated by Dr. Joseph Hyde Pratt, State Geologist and head of the State Highway Department to amount to $1,500,000. In some instances, it is stated, the roads will have to be entirely relocated. Surveys are already under way. Efforts are being made by the counties to salvage parts of bridges which remain intact, and Dr. Hyde estimates the saving will be from 25 to 60% in this way.

A Competition for Plans for the rebuilding of Dublin, Ireland, has just been completed. Announcement was made that the first of $2,000 offered by Lord Aberdeen for the best set of plans for the building and grounds of the city government of Dublin has been awarded jointly to Prof. Patrick Abercrombie, of Liverpool University, and Sydney A. Kelley and Arthur J. Kelley, both of Liverpool. F. A. C. Smith, Assistant Director of the Civic Extension Service of the Massachusetts Agricultural College, the only American contestant, received honorable mention.

Grade-Crossing Work at Detroit Is About To Be Undertaken—An agreement has been signed between the city officials and the railways contemplating the separation of grades on the west side of the city. This work will involve an expenditure of about $2,000,000, and will be started as soon as possible. The present grade separation work is nearing completion at Holden, Lincoln, Trumbull and Commonwealth Ave., and work has just been started at Kirby and Wabash Ave., 12th St., so it is not regarded as probable that the west side work will be taken up before next spring.

A New Bridge Across the Kaw River at Osage Ave., Kansas City, Kan., is contingent on the acceptance by the railroads involved of the 200-year franchise recently voted. This bridge is for the Kansas City Terminal Railway Co. If the franchise is acceptable to all the railroads, construction work amounting to $5,000,000 or $6,000,000 will be started immediately. The first piece of work will be the building of a four-track, two-deck bridge over the Kaw River to replace the present single-track structure. The new bridge will be built on the present piers and have a 300-ft. center truss span. The upper deck will not be used until after completion of the new high line viaduct crossing the bottomland on each side of the river. Contract will be awarded for the construction as soon as the new franchise is assured.

A Tropical Storm Swept Over the Coast of Texas on the night of Aug. 18 and caused considerable damage to property and killed a number of people. The storm seemed to center

at Corpus Christi, where the intensity of wind and tide height were unprecedented there or elsewhere on the Texas coast. At some distance inland from the gulf all timber structures along the water front, including the pleasure piers and wharves at San Antonio and the Aransas Pass trestle, and the cheap cottages along the beach were all badly damaged or destroyed. The causeway at Corpus Christi, which was described in "Engineering News," Mar. 30, 1916, p. 628, was also affected. About two-thirds of the fill approaches were destroyed, but the concrete bridge section is absolutely undamaged although swept by waves.

A Five-Story Tenement under construction on Marion Ave. and 187th St., the Bronx, New York City, collapsed on Aug. 23 and carried down in the fall a number of workmen, two of whom were killed and 15 were injured. The structure was of the brick and frame wall bearing type, and from testimony before a preliminary coroner's and district attorney's examination was a fine example of jerry-building. The contractor, for instance, testified that he had heard there was such a thing as a Building Code, but that he had never had time enough to read it. Violations of the code and of the design were made in substitution of stone for cast-iron templets, reduction in the strength of the mortar and in the general quality of the construction. As a result of the preliminary investigation three members of the contracting firm and three inspectors in the building department of the Bronx were arrested on a charge of criminal negligence.

Failure to Submit Falsework Drawings for the approval of the United States Engineer Office at Pittsburgh, in advance of starting construction of a reinforced-concrete arch bridge across the Allegheny River at Warren, Penn., will cause a delay in completion of several months and an estimated added cost to Warren County of $20,000 in a $125,000 structure. The contractor, the C. H. Fath Construction Co., of Cleveland, Ohio, had practically finished driving piles according to the arch centering layout shown on the design drawings when the Engineer Office reminded it that falsework plans had not been sent for approval, and after receiving them, issued an order calling for two 50-ft. openings. This was later modified to two 30-ft. openings, of 20 ft. height, for the maintenance of navigation under the River and Harbors Act of 1899. Local papers state that no craft requiring openings of this size have been seen on the river there for 20 years and that a mile below the bridge a boy can wade the shallow stream.

The Joint Conference Committee representing the National engineering societies adopted several weeks ago a resolution urging legislation by Congress to enable the development of water power ("Engineering News," June 29, p. 1254). A copy of the resolution was sent to President Wilson and he has just sent the following reply to the Secretary of the Joint Conference Committee, Charles Warren Hunt:

The White House, Washington, Aug. 25, 1916.

My Dear Mr. Hunt:

I find to my great chagrin that I have omitted to acknowledge your communication of June 28 conveying to me the resolution adopted by the Joint Conference Committee of National Engineering Societies at its meeting held on June 15, with regard to the development of the water power of the country. I the more regret the oversight because the resolution in fact made a deep impression upon me as the declaration of a body whose opinions carry the greatest weight, and I can only beg that you will present my apologies and also an expression of my sincere appreciation.

Cordially and sincerely yours,

WOODROW WILSON.

The Project for a Railway Tunnel under the English Channel at the Straits of Dover is again receiving attention in Great Britain. A committee made up of members of the House of Commons who favor the construction of the tunnel entertained a party of distinguished French visitors on July 28. The length of the tunnel would be, with approaches, about 25 mi. According to "The Engineer" of London, Baron Emile D'Erlanger, in a speech at the conference, stated that the estimated cost of constructing the tunnel was £16,000,000. The probable revenue from the tunnel is estimated as follows: Taking the annual passenger traffic across the Channel in both directions at 2,000,000 passengers, it is estimated that 65% would use the tunnel route, and at an average charge of 10s. this would produce an income of £650,000. To this is added £65,000 for baggage, £40,000 for postal service, and £800,000 for freight traffic. From the total gross earnings of £1,555,000, the operating expenses estimated at £420,000 are deducted, leaving net earnings of £1,135,000, or a little over 7% on the investment.

Sewage Pollution of Chicago's Water Supply due to flooding of some of the pumping stations on the south side with sewage last spring is to be investigated. The Department of Public Works and the Health Department have claimed that this pollution was caused through improper operation of the sewage pumping plant which handles sewage from the intercepting sewers. It is thought, however, that one prominent reason for this trouble may be found in the rapid growth of that part of the city since the interceptors were built, so that these may be overtaxed during heavy storms. The Sanitary District of Chicago, which has charge of the operation of the sewage pumping stations, has appointed a special commission to make an investigation of the 68th St. and 39th St. pumping stations and the south-side intercepting sewer system. This commission is composed of the following members: George G. Earl, Chief Engineer and General Superintendent of the Sewage and Water Board of New Orleans, La.; Isham Randolph, Consulting Engineer, of Chicago; and Lyman E. Cooley and Langdon Pearse, of the engineering department of the Sanitary District of Chicago. Mr. Randolph was for many years Chief Engineer of the Sanitary District, and Mr. Cooley has been connected with the Drainage Canal project since its inception.

PERSONALS

George H. Ruhling, of Pittsburgh, Penn., has joined the staff of E. C. Shoecraft, City Engineer of Flint, Mich.

T. R. Ratliff has been appointed Engineer of Maintenance-of-Way of the Indianapolis Union Ry., Indianapolis, Ind.

M. P. Northam, Assoc. M. Am. Soc. C. E., Office Engineer, Southern Ry., Washington, D. C., has been promoted to be Supervising Engineer.

F. B. Tapley, Assoc. M. Am. Soc. C. E., has been appointed Assistant Engineer of the Canadian Government Rys., with headquarters at Moncton, N. B.

Nelson F. Tift has been made Superintendent of the Water, Electric Light and Gas Departments of the City of Albany, Ga. He has served as Mayor, member of the Council and member of the Police Commission of the city.

Harry S. McKibben, Assoc. M. Am. Soc. C. E., City Engineer of Warren, Ohio, has resigned. Mr. McKibben is reported to have said that his resignation was made because he lacked sufficient authority to make his department efficient.

Ira G. Hedrick and Victor H. Cochrane, M.'s Am. Soc. C. E., Consulting Engineers, Kansas City, Mo., have dissolved partnership, and the firm of Hedrick & Hedrick has been formed. The junior member of the new firm is A. L. Hedrick.

Hudson F. Layton, M. Am. Soc. C. E., Consulting Engineer, Pittsburgh, Penn., has retired from active practice and has sold all his plans, notes and records to Blum, Weldin & Co., Engineers and Surveyors, St. Nicholas Building, Pittsburgh.

P. J. Freeman, Assoc. M. Am. Soc. M. E., has resigned as Assistant Professor of Applied Mechanics at the Kansas State College, Manhattan, Kan., and is now with the Pittsburgh Testing Laboratory, Pittsburgh, Penn., as Engineer of Tests.

R. J. Lockwood, Assoc. M. Am. Soc. C. E., Vice-President and General Manager of the New Iberia & North R.R., New Iberia, La., has been appointed Vice-President and General Manager of the Apalachicola Northern R.R., with office at Port St. Joe, Fla.

F. M. Masters, Assoc. M. Am. Soc. C. E., for several years Chief Inspector in the Pittsburgh (Penn.) district for Modjeski & Angier, Consulting Engineers, Chicago and Portland, Ore., has resigned to enter private practice as Inspecting Engineer, with headquarters at Harrisburg, Penn.

Dr. William McClellan, F. Am. Inst. E. E., Consulting Engineer, New York City, has been appointed Dean of the Wharton School of Finance and Commerce of the University of Pennsylvania. Dr. McClellan is a native of Philadelphia and was graduated from the University of Pennsylvania in 1900. For two years, 1911-13, he was Electrical Engineer of Public Service Commission of the Second District, New York State.

George F. Weighardt, Assistant Engineer of the Pennsylvania State Water Supply Commission, has resigned to become Assistant Water Engineer for the City of Baltimore, Md. Mr. Weighardt became connected with the Pennsylvania Commission in 1913 and was stationed at Cotesville, where he supervised construction of a large dam. He succeeds Robert L. Clement, who resigned after being connected with the Baltimore water department for 30 years. Mr. Weighardt is a graduate of Cornell University. He assumes his new duties Sept. 3.

The American Industrial Commission to France, organized by the American Manufacturers' Export Association, includes several men prominent in engineering; among them are: John R. MacArthur, of MacArthur Brothers, General Contractors, of New York City; Dr. C. O. Mailloux, F. Am. Inst. E. E.,

Consulting Engineer, New York City; N. F. Hoggson, President of Hoggson Brothers, Inc., Contractors, New York City; Ambrose Swasey, M. Am. Soc. M. E., President of Warner & Swasey, Cleveland, Ohio; George B. Ford, of George B. Post & Sons, Contractors, New York City, and James E. Sague, M. Am. Soc. M. E., Poughkeepsie, N. Y., former Vice-President of the American Locomotive Co. The Chairman of the commission is William W. Nichols, M. Am. Soc. M. E., Assistant to the Chairman of the Board of Directors of the Allis-Chalmers Manufacturing Co., of New York City. The commission sailed Aug. 26 for France where it will make a scientific study of the industrial conditions, to determine the most advantageous method of assisting in the reconstruction that will follow the war.

OBITUARY

Henry Clay Malott, a retired civil engineer and contractor, died recently at his home in Bedford, Ind., aged 72 years.

Archibald Case, a young civil engineering employee of Snare & Triest, contractor for the completion of the concrete tower tops of the Hell Gate arch bridge, New York Connecting R.R., was killed Aug. 25 by a box falling upon him from the bridge superstructure.

Edward Canfield, M. Am. Soc. C. E., General Superintendent of the New York, Ontario & Western R.R., died Aug. 19, at his home in Middletown, N. Y. He was born in 1848 and was graduated from Hobart College at Geneva, N. Y., in 1869. He began his engineering experience with the Erie & Genesee Valley R.R. the same year. He served as Assistant Engineer and as Division Engineer of various Eastern railways until 1882, when he entered the operating department of the New York, Ontario & Western R.R. as Division Superintendent. For seven years, 1887 to 1895, he was Chief Engineer of the railway, and since then General Superintendent.

Sinclair J. Johnson, a civil and mechanical engineer, died at his residence in Montclair, N. J., on Aug. 11, aged 64 years, after a lingering illness. He was a native of Wayne County, Ohio. After graduation from Wooster College he studied civil engineering at the Thayer School of Dartmouth College, Hanover, N. H. He was engaged for a number of years in civil engineering work, including water-works construction and the design and erection of steel buildings. He had much originality as an inventor and developed a number of devices which he patented for use in railway-car construction and a hydraulic system of power transmission. A wife and five daughters survive him.

John Dean, a retired civil engineer and contractor, died Aug. 17, at his home in Chicago, Ill. He received his engineering education at Owens College, Manchester, England. He came to this country in 1885 and was engaged in engineering work for several Middle Western railways. Later he was Engineer of Parks of St. Louis, Mo. As a contractor he did extensive work in grading and concrete bridge building during the early nineties. Afterward he had construction contracts on the Grand Trunk Ry. and for the cities of St. Louis, Mo., Manistee, Mich., and Des Moines, Iowa. He was for many years a member of the Engineers' Club of St. Louis and of the American Railway Engineering Association. He is survived by a widow and one son, Stanley Dean, Assoc. M. Am. Soc. C. E., a civil engineer of Chicago.

John Noey, one of the pioneers of the Pennsylvania steel industry, died Aug. 23, aged 65 years. The following is from the Pittsburgh "Gazette-Times" of Aug. 25:

He was born in Johnstown, Penn., a son of John Noey, Sr., and came naturally by his skill in mechanics, his father having been one of the pioneer employees of the old Cambria Iron Co.'s plant at Johnstown, now the Cambria Steel Co. John Noey, Jr., entered the employ of the Cambria Steel Co. and was a protege of the late Capt. William R. Jones, the builder, with Andrew Carnegie, of the Edgar Thomson Works and Mr. Carnegie's first partner in the steel business. When Captain Jones went to Braddock in 1874 to build the Edgar Thomson mills he took Mr. Noey with him. At the time of his death Mr. Noey was superintendent of the boilers and of motive power at the Thomson steel works and blast furnaces. When Andrew Carnegie established his "junior partners'" fund 16 or 17 years ago, before his retirement, in recognition of the loyalty and service given by his employees at the first plant, Mr. Noey was made one of the "junior partners."

Stehman Forney, an officer of the United States Coast and Geodetic Survey since 1865 and a veteran of the Civil War, died in New York City, Aug. 8, in the 71st year of his age. He was born at Lancaster, Penn., Apr. 22, 1846, and was educated at Lebanon, West Chester and Lititz academies, in Pennsylvania. He entered the Coast Survey as Aid, Jan. 1, 1865; was promoted to Subassistant July 1, 1868, and was appointed an Assistant Apr. 1, 1871. Mr. Forney's service in the Coast and Geodetic Survey was of a varied nature. He served with Prof. George Davidson in Alaska when that Territory was transferred to the United States by Russia in 1867. He served on both the Atlantic and Pacific coasts and in Porto Rico in charge of parties engaged in triangulations, topographic and hydrographic work. The last fieldwork upon which he was engaged was a revision of the surveys in the vicinity of Oyster Bay, Long Island, N. Y. For a time he was in charge of the engraving division of the Coast and Geodetic Survey office.

ENGINEERING SOCIETIES

INTERNATIONAL ASSOCIATION OF FIRE ENGINEERS.
Aug. 29-Sept. 1. Convention in Providence, R. I. Secy., James McFall, Roanoke, Va.

ASSOCIATION OF EDISON ILLUMINATING COMPANIES.
Sept. 4-7. Convention in Hot Springs, Va. Asst. Secy., E. A. Baily, 360 Pearl St., Brooklyn, N. Y.

AMERICAN FOUNDRYMEN'S ASSOCIATION.
Week of Sept. 11. Annual meeting in Cleveland, Ohio. Secy., A. O. Backert, 12th and Chestnut St., Cleveland, Ohio.

AMERICAN INSTITUTE OF METALS.
Week of Sept. 11. Meeting in Cleveland, Ohio. Secy., W. M. Corse, 106 Morris Ave., Buffalo, N. Y.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS.
Sept. 11-16. Convention, Minneapolis, Minn. Secy., Fred W. Raven, 417 S. Dearborn St., Chicago.

MASTER CAR AND LOCOMOTIVE PAINTERS' ASSOCIATION.
Sept. 12. Convention in Atlantic City. Secy., A. P. Dane, Reading, Mass.

RAILWAY SIGNAL ASSOCIATION.
Sept. 12-14. Convention in Mackinac Island. Secy., C. C. Rosenburg, Myers Building, Bethlehem, Penn.

NEW YORK STATE ASSOCIATION OF COUNTY SUPERINTENDENTS OF HIGHWAYS.
Sept. 13-14. Meeting at Syracuse. George S. Tibbits, Chairman of Executive Committee, Oneida, N. Y.

NEW ENGLAND WATER-WORKS ASSOCIATION.
Sept. 13-15. Convention in Portland, Me. Secy., Willard Kent, Narragansett Pier, R. I.

ILLUMINATING ENGINEERING SOCIETY.
Sept. 18-20. Convention in Philadelphia, Penn. Asst. Secy., C. D. Fawcett, 29 West 39th St., New York, N. Y.

ASSOCIATION OF IRON AND STEEL ELECTRICAL ENGINEERS.
Sept. 18-22. Convention in Chicago. Secy., W. O. Oschmann, Oliver Iron and Steel Co., Pittsburgh, Penn.

ROADMASTERS AND MAINTENANCE OF WAY ASSOCIATION OF AMERICA.
Sept. 19-22. Convention in New York City. Secy., P. J. McAndrews.

AMERICAN PEAT SOCIETY.
Sept. 21-23. Annual meeting in Washington, D. C. Secy., Julius Bordollo, Kingsbridge, N. Y.

AMERICAN CHEMICAL SOCIETY.
Sept. 25-30. Annual meeting in New York City. Secy., Charles L. Parsons, Washington, D. C.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Oct. 9-13. Convention in Newark, N. J. Secy., Charles C. Brown, Indianapolis, Ind.

AMERICAN ELECTRIC RAILWAY ASSOCIATION.
Oct. 9-13. Convention at Atlantic City, N. J. Secy., E. B. Burritt, 8 West 40th St., New York City.

AMERICAN RAILWAY BRIDGE AND BUILDING ASSOCIATION.
Oct. 17-19. Convention in New Orleans. Secy., C. A. Lichty, C. & N. W. Ry., Chicago.

AMERICAN GAS INSTITUTE.
Oct. 17-20. Annual meeting in Chicago. Secy., G. G. Ramsdell, New York, N. Y.

AMERICAN PUBLIC HEALTH ASSOCIATION.
Oct. 24-27. Convention in Cincinnati, Ohio. Secy., Prof. Selskar M. Gunn, Boston, Mass.

The New York State Association of County Superintendents of Highways will hold its annual meeting in Syracuse, Sept. 13 and 14. The chairman of the executive committee is George S. Tibbits. The secretary is Dwight B. Coleman.

The Traveling Engineers' Association has decided to postpone its convention scheduled for Sept. 5 to 8 on account of the serious labor conditions on the railways. The secretary is W. O. Thompson, general offices, New York Central R.R., Cleveland, Ohio.

A Good Roads Congress in San Antonio, Tex., was held Aug. 17 to 19, under the auspices of the Texas Good Roads Association. D. E. Colp, secretary.

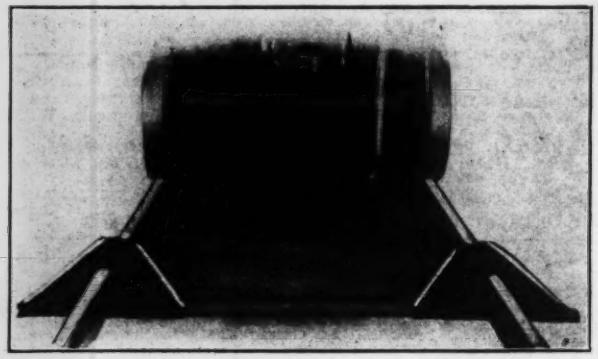
National Paving Brick Manufacturers Association has arranged the details necessary for a study and conference of brick-pavement construction, to take place Friday, Oct. 6, at Paris, Ill. The headquarters of the conference will be the Deming Hotel, Terre Haute, Ind., from which place those participating will go via the Interurban Ry. to Paris—an hour's ride—where a demonstration of construction will take place. This demonstration is designed to show the economy of building a brick pavement by laying the brick in green mortar (so-called monolithic construction). Members of the

American Society of Municipal Improvements on their way to the annual meeting of the Society at Newark, N. J., can spend Oct. 6 at this conference and reach Newark the following Monday. All those expecting to take part in this conference are requested to notify the Secretary of the National Paving Brick Manufacturers Association, Will P. Blair, Cleveland, Ohio, in order that they may be fully informed of the program, arrival and departure of trains, etc.

Appliances and Materials

Rerailer for Dump-Cars

A contractor's utility, known as the "Johnson Car Replacer," is now made by the Johnson Wrecking Frog Co., of Cleveland. It is intended particularly for putting dump-cars



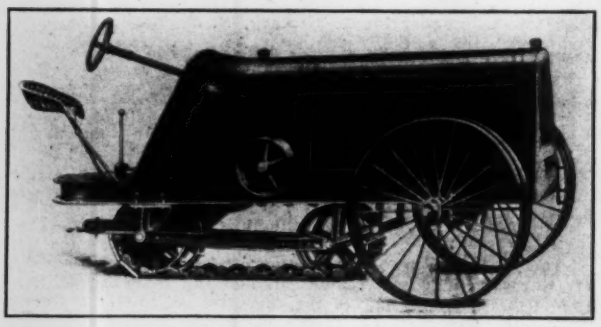
JOHNSON CONTRACTOR'S CAR REPLACER

back on the track. The use is obvious from the accompanying view. The device is an openhearth-steel casting, ground smooth at the places of contact with the rails. It is sold by Clapp, Norstrom & Riley, 12 South Canal St., Chicago.

* * *

A Tractor for Light Contract Work

The tractor illustrated herewith is guaranteed to develop 20 hp. on the belt and 12 hp. on the drawbar. It is manufactured by the Tom Thumb Tráctor Co., of Minneapolis, bears the same name as the company and is designed primarily for farm work. The motor is of Waukesha make, having four vertical cylinders, a 4½-in. bore, 5¾-in. stroke and a speed



TOM THUMB TRACTOR FOR SMALL CONTRACTOR AND FARMER

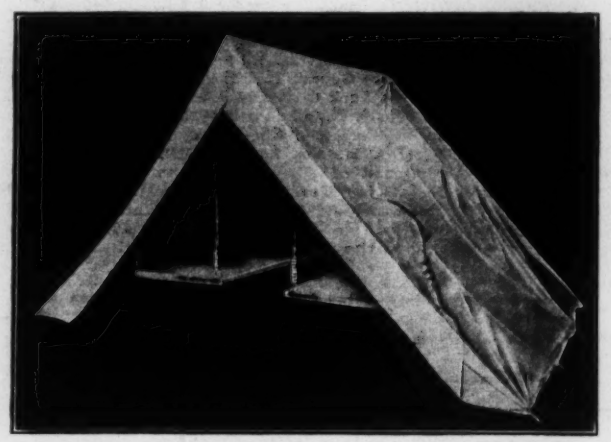
of 800 r.p.m. The tank can contain 20 gal. of gasoline. The speed of the tractor is 2.7 mi. per hr. on high and 2.1 mi. on low gear. The steering wheels are 42 in. in diameter with 8x3-in. tires.

The machine complete weighs 5,000 lb., which figures to about 5½ lb. per sq.in. of contact surface. The machine can be turned either way, both backward and forward, in a 15-ft. circle.

* * *

Portable Tent and Bed Outfit

A new A-tent frame with two hanging bunks is being made by the Gosso Co., of Chicago, for survey and construction camps. The tent is 8½ ft. long, 11 ft. wide and 6½ ft. high. The frame consists of angle-iron A-ends connected by an angle ridge and fitted with round knee braces and



GOSSO TENT WITH BUNKS

wire ties around the bottom. Canvas bunks are swung by wires and springs from the end-frame legs. They fasten back against the sides when not in use. Legs, ridgepole and bottom sides are hinged, so that all can be folded to 4 ft. 8 in. in length.

* * *

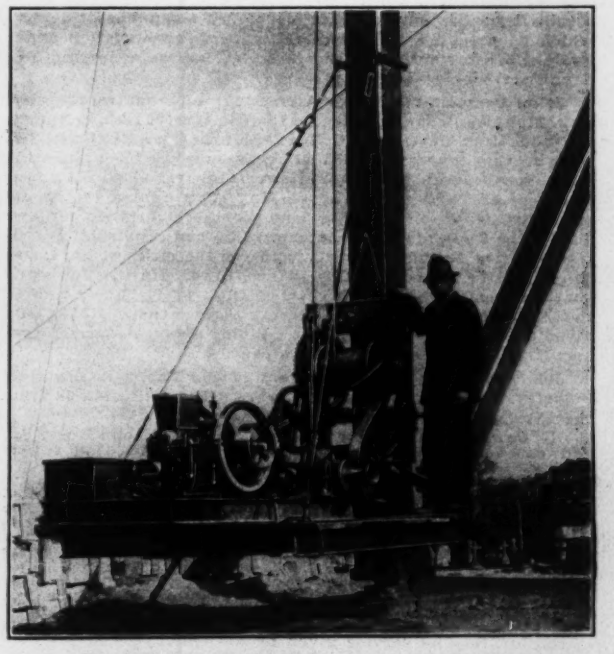
"Daylight" Electric Lamps

For special service where a color quality of illumination approximating daylight is required, as in displays, color printing shops, textile mills, etc., small nitrogen-filled tungsten-filament electric incandescent lamps, requiring 40 and 60 watts input, are being made with "Lunar" blue glass bulbs. They are being put out by the Lux Manufacturing Co., Hoboken, N. J.

* * *

Power Hoist for Attachment to Hand Guy Derricks

Hoisting outfits for taking the place of manual labor on guy derricks are sold in three sizes—3½, 5 and 7 hp.—by the Domestic Engine and Pump Co. of Shippenburg, Penn. The unit consists of engine, jack-shaft with clutch, two winch-



POWER HOIST ON HAND DERRICK

heads and a platform that can be attached to the mast as a mounting for the hoist. The outfit can erect both itself and the derrick.

The smallest unit is intended for use with derricks having 12-in. or 14-in. masts; the larger units with 14- or 16-in. masts. The prices of the complete rigs are $372, $412 and $462 respectively.